東京大學理學部紀要

第二類　地質学 鉱物学 地理学 地球物理学

第十二冊　第一篇

QE
1
T5
vol. 12
N/C

JOURNAL

OF THE

FACULTY OF SCIENCE

UNIVERSITY OF TOKYO

SECTION II

GEOLOGY, MINERALOGY, GEOGRAPHY, GEOPHYSICS

Vol. XII Part 1

Tokyo Daigaku. Rigakubu

TOKYO

Published by the University

Dec. 15, 1959

161

The "JOURNAL OF THE FACULTY OF SCIENCE" is the continuation of the "JOURNAL OF THE COLLEGE OF SCIENCE" published by the University in forty-five volumes (1887–1925), and is issued in five sections:

Section I.—Mathematics, Astronomy, Physics, Chemistry
Section II.—Geology, Mineralogy, Geography, Geophysics
Section III.—Botany
Section IV.—Zoology
Section V.—Anthropology

Committee on Publication

Prof. T. YAMANOUCHI, Dean, *ex officio*
Prof. M. HUKUHARA
Prof. T. KOBAYASHI
Prof. F. MAEKAWA
Prof. K. TAKEWAKI
Prof. H. SUZUKI

All communications relating to this Journal should be addressed to the DEAN OF THE FACULTY OF SCIENCE, UNIVERSITY OF TOKYO.

QE
1
T5
Vol. 12
N/C

DAONELLA IN JAPAN*

By

Teiichi KOBAYASHI and Akira TOKUYAMA

With I—IV Plates

I. Introductory Note

This is a companion paper with "*Halobiae* in Nippon" by AOTI and the senior author in 1943 and consists of the following 4 parts:

1. *Daonella* from Zohoin in Sakawa basin
2. *Daonella* in the Japan Province
3. Note on the Distribution of *Daonella*
4. Description of *Daonella* in Japan

The genus is represented in the Triassic of Japan by 15 species in addition to 2 subspecies, including 5 new species and 2 new subspecies, with which 5 in 8 groups of KITTL's classification are represented. They are distributed in the Rifu, Zohoin and Atsu series, but each has its own assemblage of species. Therefore 3 zones can be distinguished as follows:

3. *Daonella yoshimurai* zone in the Ladino-Carnic Atsu series
2. *Daonella subquadrata* zone in the upper Ladinic Zohoin series
1. *Daonella multistriata* zone in the lower Ladinic–upper Anisic Rifu series

Daonella as a genus was most flourished in the Alpine or Tethyan geosyncline in the Ladinic epoch. While 2 species of the Rifu series are closely related to *D. americana* and SMITH's *D. moussoni*, most others of the two other species show affinities with the Alpine and Tethyan species. Most species of *Daonella* so far reported from Ussuri have close relatives in Japan.

A brief note is added to the end of this monograph to supplement to *Halobiae in Nippon*.

II. *Daonella* from Zohoin in Sakawa basin

Zohoin in Sakawa basin, Kochi Pref. (Prov. Tosa) is the most famous locality of *Daonella* in Japan known from the cradle of her geologic research. MOJSISOVICS (1888) was the first to describe *Daonella* of two new species, *kotoi* and *sakawana*, from this locality. Subsequently, studies on *Daonella* of Zohoin were repeated by KITTL, 1912, DIENER, 1915, YABE and SHIMIZU, 1927 and the senior author, 1931. In the study on the Rifu fauna, YABE and SHIMIZU (1927) classified the *Daonella* from Zohoin into 3 species and 2 varieties, where *Daonella kotoi* var. *alta*, *Daonella densisulcata* and its variety *subquadrata* were new. They correlated the *Daonella* bed of Zohoin with the upper *Daonella* bed of Rifu, Prov. Rikuzen (Miyagi Pref.) because *densisulcata* was common between them. SHIMIZU (1930) reported the occurrence of *Protrachyceras* aff. *archelaus* (LAUBE) and *This-*

*) Received May 22, 1959; read at the 73rd meeting of the Palaeontological Society of Japan at Fukuoka, May 23, 1959.

bites orientalis SHIMIZU in the series, where the former species is well known as an upper Ladinic zone index. This agrees with the chronology that the senior author (1931) reached by his preliminary study. At that time he distinguished the Zohoin collection into 4 species and 4 varieties including *Daonella indica* and 3 new varieties. In 1927 YEHARA proposed Zohoin series for the Middle Triassic formation of the Sakawa basin. Later however, it was found that his Zohoin series includes much of the Permian. Therefore the senior author (1931) restricted the usage of the Zohoin series to the *Daonella* bed.

It is composed mainly of dark gray or black mudstone beside some sandstone intercalations. Its type locality is a small narrow low hill adjacently to the east of Sakawa town. Almost all fossils collected at this locality belong to *Daonella*. *Pseudomonotis ochotica* was reported therefrom by MOJSISOVICS erraneously, as noted by DIENER, YABE and SHIMIZU and the senior author, because *ochotica* has never been actually procured from Zohoin, notwithstanding the fact that innumerable collectors have visited there. "*Gervillia*" and a few ammonites may be all other fossils so far known from Zohoin.

The Zohoin collection which was accumulated in this institute by Prof. B. KOTO and many others is a large one comprising various forms and constitutes the main objects of this study. Naturally they must be brought into comparison with *Daonella* from Rifu and other localities. In 1940 Prof. HANZAWA invited the senior author to Sendai to give a lecture on the Geology of Eastern Asia. During this stay he could make a study on YABE and SHIMIZU's types from Rifu and Zohoin. Furthermore he was fortunate to have happy opportunities to study many originals of SMITH, MOJSISOVICS and others at his visit to Washington D.C., Wien and Bonn during the years from 1931 to 1934. On this occasion the author wishes to record his sincere thanks to Dr. R.S. BASSLER of the U.S. National Museum, the late Dr. John B. REESIDE of the U.S. Geological Survey, the late Prof. J. PIA of the Naturhistorishes Museum zu Wien, the late Prof. J. WANNER of the Universität zu Bonn and Prof. S. HANZAWA of the Tohoku University at Sendai.

In 1943 when the senior author has published *Halobiae in Nippon* with AOTI, it was his plan to take up *Daonella in Japan* in the next step. It was soon attempted with HUKASAWA and then with ISHII. Interrupted by other works however, the material was left untouched for more than ten years. Recently he resumed it with assistance of the junior author.

As the result 11 species and 2 subspecies are distinguished and referred to KITTL's groups as follows:

2nd group of *moussoni*
Daonella tenuistriata KOBAYASHI & TOKUYAMA, new species

3rd group of *tyrolensis*
Daonella alta YABE & SHIMIZU
Daonella indica BITTNER
Daonella cfr. *spitiensis* BITTNER
Daonella iwayai KOBAYASHI & TOKUYAMA, new species
Daonella kotoi MOISISOVICS
Daonella sakawana MOJSISOVICS

4th group of *sturi-lommeli* (?)
Daonella subquadrata YABE & SHIMIZU
Daonella subquadrta zohoinensis KOBAYASHI & TOKUYAMA, new subspecies
Daonella subquadrata symmetrica KOBAYASHI & TOKUYAMA, new subspecies

5th group of *grabensis*
Daonella pectinoides KOBAYASHI & TOKUYAMA, new species

6th group of *pichleri*
Daonella asymmetrica KOBAYASHI & TOKUYAMA, new species
Daonella hiratai KOBAYASHI & TOKUYAMA

In this collection *subquadrata* (inclusive of 2 subspecies) is most abundant and *indica* and *kotoi* are the next. The other species are rare. Systematically, they are included in KITTL's 2nd to 6th groups. *D. tenuistriata* is aberrant and not typical of the second group but more or less related to the third group. *D. alta* is typical of the third group which comprises many relatives in the Tethys fauna. *Indica* is widely distributed in the Tethys-Asiatic region in the upper Ladinic to the lower Carnic. In Portuguese Timor it occurs in the *reitzi*- or *lommeli*-zone of the autochthonous Trias, and in the Trias of the Deckencomplex it coexists with *D.* aff. *kittli* (WANNER, 1956). In the Himalayas, it is stated by DIENER (1912) that "there is no distinct stratigraphical horizon characterized by the presence of *Daonella indica*, as had been suggested by BITTNER." There the *indica*-horizon overlies the *archelaus*-zone and *indica* is sometimes collected from the lower Carnic. In the Alps, it is found most often in the Esino and Marmolata stages and sometimes in the Cassian stage or *aon*-zone (KITTL, 1912). *Spitiensis* is a member of the *indica*-group in the lower part of the zone in Spiti. *Iwayai* is related to *arzelensis* KITTL from the upper Ladinic Wettersteinkalk stage of Innsbruck and cfr. *bulogensis* by KRUMBECK from Timor. Therefore this is also of the Tethys-Asiatic fauna. *Kotoi* and *sakawana* are, though not typical of this group, allied to some inequilateral forms of the group such as *kittli*, *latecosta* and *tripartita*. The "Formenkreis" of *subquadrata* to which *lilintana* is included, is distributed in Indonesia, Timor, and the Himarayas. The *pichleri* group, to which *asymmetrica* and *hiratai* is included, is also distributed widely in the Tethys-Asiatic regions. While *pichleri* is found commonly in the Alps, KRUMBECK described its subspecies from Timor. A very unusual form is *hiratai* but its ally is found in VOLZ's Sumatra-fauna. Finally, *pectinoides* is a relative of *zellensis* which is a common Tethys member.

In short all Zohoin species of *Daonella* but the first are comparable with Tethys and Asiatic species. *Subquadrata*, *indica* and *spitiensis* are all common Asiatic members, while *alta* and *pectinoides* are relatives of Tethys elements and the *pichleri* group has more species in Tethys than Asia. The Alpine relatives suggest upper Ladinic for the Zohoin series. The *tyrolensis* group is distributed in the Esino stage or the lower *archelaus* zone. *Indica* ranges from the Buchenstein stage or the *reitzi* zone to the Cassian stage. *Pichleri* found in the Wengen stage or the upper *archelaus* zone, and the group of *zellensis* occurs in the Cassian stage. Therefore, ignoring the aberrant forms, the Zohoin fauna can be safely correlated with the Ladinic ones in the Alps.

The Zohoin specimens of *Daonella* are all internal and external moulds. Because the test is gone, its thickness is actually immeasurable. It can be presumed, however, that the shell was not thick, because the difference of ribbing between the two moulds is inconcievable.

Two valves of *Daonella hiratai* are wide open but still united. There are a few other examples of such preservation. All others are, however, separate valves. Nevertheless their outlines are generally undamaged. Because the hinge and muscles are poor in *Daonella*, two valves are easily separable from each other. Detached valves are scattered or crowded on slabs, but they are never

so much accumulated as can be called a shell bank. The shells often lie with their convex side above, but the reverse orientation is not rare. It is noted on some slabs that umbones are directed to a certain similar direction. It is remarkable also that some slabs contain only small shells. As a tendency small shells may be said rare or very uncommon where large and medium sized ones are found abundant. The small shells which are not far removed from the *Posidonia*-like stage are not dwarfs, but immature shells. Then, what does the difference in the shell size of the crowd mean? Does it have something to do with the hatching season? It is probable also that mature and immature shells were sorted by wave of current.

At all events the Zohoin fauna is an interesting example of overwhelming majority of a certain genus in a small fauna. Its number of the known genera is reduced to 2, if the ammonites are exotic floats. *Daonella* is rich not only in number of individuals but also in the number of species and subspecies. It is indeed an extraordinary profusion to find 12 species of *Daonella* in addition to 2 subspecies at one locality. It must not be overlooked, however, that the majority of *Daonella* belongs to 3 species, or precisely speaking, more than a half or approximately 3/5 to *subquadrata* and its two subspecies, about a quarter or a fifth to *kotoi* and a fifth or so to *indica* plus cfr. *spitiensis*. In the remaining 7 species 6 are each represented by a single specimen. This sensus shows that more than 95% of the Zohoin fauna are occupied by 3 species of *Daonella*. Their prosperity means that the muddy bottom of Zohoin in the Ladinic sea has been particularly favourable for them.

The occurrences of these species are restricted to Shikoku island or the Sakawa basin, except for *D. indica* which is widely distributed from the Alps to Japan through the Himalayas and South China and *D. spitiensis* known from Spiti. Compared to the large forms of *indica* in the calcareous facies the Japanese examples of the species are smaller. *D. spitiensis* is also a little larger than *D.* cfr. *spitiensis*. Mature shells of the other Zohoin species seem to be near the average size of *Daonella*.

Because these shells are thin but undamaged, their habitat is inferred to have had a tranquil bottom of moderate depth, although it was agitated by current or had waves at least temporarily, seeing that two valves are mostly separated from each other and many shells take stable orientation. In many characteristics the *Daonella* bed of Zohoin resembles the so-called *Posidonienschiefer*.

The shells of *Daonella* are nearly flat except the umbonal region which is a little inflated. It is difficult to say about the original convexity, because it is indeterminable how far the shell was depressed secondarily. However, it is noteworthy that the shells are mostly flattened without yielding any visible cracks. This is probably because thin shells were flattened extremely slowly by compaction of mother rock. There are of course some cracks which were probably products by deformation of mother rock. The secondary deformation of the shell outline varies to some degrees among the specimens. In an immature specimen of *subquadrata* two valves are nearly identical in outline, but it is quite obvious in the holotype of *hiratai* that its two valves are diagonally compressed to some extent. There is, however, no specimen from Zohoin which is so strongly deformed that its specific identification is made impossible.

III. *Daonella* in the Japan Province

In Japan *Daonella* occurs in the Zohoin series in Kochi and Tokushima Pref. (Prov. Tosa and Awa), the Atsu series in Yamaguchi Pref. (Prov. Nagato), the Rifu series in Miyagi Pref. (Prov. Rikuzen) and probably its equivalent in Kyoto Pref. (Prov. Tamba). Recently NAKAZAWA (1958) reported *Daonella* (?) sp. with *Nuculana* sp. and *Monophyllites* cfr. *sphaerophyllus* from the top of the Oro formation in Kyoto Pref. It was however, too fragmentary to make an exact determination.

Previously the senior author (1931) has described *Daonella* cfr. *kotoi* var. *alta* and several other fossils from the Sambosan limestone at Sambosan, Kami-gun, Kochi Pref. and suggested Ladino-Carnic age for this fauna. Because of imperfect preservation, however, the reference to *Daonella* cannot be warranted. Lately the junior author (1957) found that *Rhynchonella sambosanensis* belongs to *Holcorhynchia* whose range is Carnic to Dogger. Therefore he suggested Carnic for the age of the limestone. It seems then probable that the *Daonella* in question is a *Halobia*.

Beside Zohoin *Daonella* occurs in the Zohoin series at Okazaki-goe adjacently west of Sakawa town and Yokoyama-dani to the northeast of Zohoin. The strip of the series extends farther to the east into Ino area from the basin. There HIRATA (1939) discovered three localities, i.e. (1) west of Okuna, (2) between Okuna and Kuroiwa-dani and (3) Kuroiwa-dani to which (4) Koretomo between Ino and a locality at Konai was later added by YAMAMOTO, OKUMURA and NISHIMURA (1941).

The *Daonella*-bearing rocks at these 4 localities of Ino area as well as at Okazaki-goe are similarly fine yellowish slabs altered from the black shale of the Zohoin type, but somewhat finer than the typical Zohoin specimens. It is a remarkable fact that most shells are small and undamaged. The *Posidonia*-like stage is often seen in the umbonal region of about 1 mm or less. The immature shells are commonly 5 to 10 mm long, but a complete specimen attains the length of 2 cm. This collection comprises only a few large but imperfect ones. Fragments of large shells are, however, not rare. These shells and fragments are gregarious on bedding planes. This aspect combined with the fact that there is no example of two valves united suggests the effect of sorting of some strength for the gregarious occurrence of the shells. "*Natica*" sp. and "*Dentalium*" sp. are reported as two associates with *Daonella* in Ino area.

As most shells are either immature or imperfect, their taxonomy cannot be very accurate. Most of them are, however, identifiable with *indica*, *kotoi* and *subquadrata zohoinensis* where *indica* is characterized by high outline, *kotoi* by rounded and diagonally prolonged outline and flattened wide ribs and *subquadrata zohoinensis* by the fairly developed *Posidonia*-like stage, diagonally elongated outline and numerous ribs. Beside them there is a common form which is an unnamed variety of *kotoi* having flat trifurcated ribs in the median part.

Stimulated by the find of *Daonella* and other Mesozoic fossils in Tokushima Pref. by SHINOHARA (1941), the senior author carried out the geological survey with IWAYA (1941) with the result that the highly complicated imbrication of Sakuradani was brought to light. On this occasion *Daonella* was found at Usugatani, Fujinohira, Gorodani and Junisha in the Zohoin series of the Fujinohira Decke. Later HIRATA (1950) found *Daonella* at Semidani in the western extension of the series, while SUYARI (1958) discovered *Daonella* in a mudstone at Kumagatani, Tomioka-town which is most eastern locality of the series in Shikoku island. YAMASHITA and others (1956) proposed "Usugatani formation" for the

Daonella bed in Tokushima Prefecture, but it is a superfluours name because there is no question about its synonymy with the Zohoin series.

In comparison with yellowish slabs of Ino the *Daonella* shale of Sakuradani area is more coarse grained and its colour dark grey or black. The most common member is *indica*, followed by *subquadrata* and *subquadrata symmetrica*. *Kotoi* is common in Sakuradani as well as in Ino area; *pectinoides* is a rare species in Zohoin; but common in Sakuradani. *Trachyceras* (*Protrachyceras*?) 2 spp. are reported from Junisha and Inotani on the opposite side of Fujinohira and *Ptychites* (?) from Gorodani, but none of them is as yet described.

In Sakawa–Ino area the Zohoin series lies on the Permian or the Permo-Triassic on the south side. It forms an arcuate strip delimited by a thrust from the northern zone where the Permian formation and the Upper Triassic Kochigatani series exist. Likewise in Sakuradani area the Fujinohira Decke which bears the Zohoin series is thrust from the north by the low angled Hisone Decke where the Kochigatani is found. The northerly lapping of the Kochigatani over the Zohoin series is noteworthy because it reveals the regression which has taken place in the peri-orogenic zone of the Akiyoshi mountains in the late Ladinic epoch.

In the inner zone of West Japan the senior author (1935) has described *Daonella yoshimurai* from the Atsu series at Shirogahara, Mine city, Yamaguchi Pref. It has several wide, weak, flat-topped ribs only in the median part and undoubtedly belongs to KITTL's *moussoni* group. Recently the junior author added 2 species of *Halobia* and one of *Oxytoma*, all new (1959). The *Daonella* horizon lying conformably below the lower Carnic Hirabara formation is in the upper part of the Atsu series. Therefore its age is generally accepted to be latest Ladinic, if not earliest Carnic.

In North Japan the occurrence of *Daonella* was first reported by YABE from Rifu, north of Sendai, Miyagi Pref. Later YABE and Shimizu (1927) divided the Rifu series into the upper and lower *Daonella* beds and subdivided the lower one into the upper or *Monophyllites* zone and the lower or *Ptychites* zone. The Rifu fauna is a rich one comprising 25 forms in *Spiriferina*, *Myoconcha*, *Pleuronautilus*, *Gymnotoceras*, *Hollandites*, *Beyrichites* and other Molluscan genera which are related partly to the Middle Triassic of Himaraya and partly to the fauna of the Star Peak formation of the *Daonella dubia* zone of Nevada. *Daonella kotoi* var. *multistriata* and *Daonella densisulcata* were described from the upper *Daonella* bed and the *Monophyllites* zone, but no *Daonella* is contained in the *Ptychites* zone. YABE and SHIMIZU considered the fauna to be Ladinic in age and correlated the upper *Daonella* bed to the Zohoin series, because *D. densisulcata* occurs also at Zohoin. Their *D. densisulcata* of Zohoin, however, is *D. subquadrata* subsp. *zohoinensis*. Because there is no species of *Daonella* common between the Zohoin and Rifu series and because the Rifu fauna reveals affinities with the Anisic ones, the Rifu fauna is a little older than the Zohoin and probably Ladino-Anisic. According to NAKAZAWA and ICHIKAWA (1951) the structure exposed at the cutting of Rifu is a monocline, instead of an anticline as understood by YABE and SHIMIZU. Accordingly the above zonation becomes doubtful. Recently BANDO (1958) found *Protrachyceras* cfr. *reitzi* in addition to *Ptychites*, *Tropogastrites*, *Gymnites*, *Megalodus* and others and located the Rifu series at lower Ladinic. The two Rifu species of *Daonella* are closely related to *D. americana* and SMITH's *moussoni* and specifically distinct from any of the Zohoin and Atsu series. This conclusion matches with the general aspect of ammonites which appears most

related to that of the *dubia* zone which is in turn considered Anisic by MULLER (1939), although *P.* cfr. *reitzi* is contained as ons of a few allies to the Alpine or Tethys fauna. Therefore it is more reasonable to extend the range of Rifu from lower Ladinic to upper Anisic than to restrict to lower Ladinic. The Rifu series is exposed at a few places beneath Neogene blanket. Its stratigraphic relation to the Anisic *Hollandites* beds of the Inai series in the southern Kitakami mountains is indeterminable.

As discussed already, the Zohoin fauna is a correlative of the upper Ladinic *archelaus* zone or *lommeli* zone. *Daonellae* of the Zohoin series comprise several close relatives of the Tethyan species beside *indica* which was wide spread from the Alps to Japan through the Himaraya, South China and Indonesia. The stratigraphic relation of this series to the Kochigatani is also yet unsolved, because they are distributed in different tectonic belts.

In Yamaguchi Pref. the Mine series overlies the Atsu and overlapping the latter, the former extends toward the north. The two series yield no ammonites, but the age of the Mine series can be determined by *Halobia* and other pelecypods (KOBAYASHI & AOTI, 1943, TOKUYAMA, 1959).

As discussed above, three *Daonella* zones are distinguished in Japan, where the middle one reveals the acmic prominence. The *yoshimurai* zone where *Daonella* and *Halobia* are coexistent is transition from the *Daonella* to the *Halobia* epoch in Japan.

ICHIKAWA proposed Matsushiman for the Rifu fauna, while he combined the Zohoin and Atsu faunas in his Fujinohiran, notwithstanding the fact that no species is common between the Zohoin and Atsu faunas. By this reason the senior author emphasized that they are two distinct units. In agreement with this opinion, NAKAZAWA segregated the latter part out of the Fujinohiran for which he proposed Arakuran, in taking the Arakura formation in Kyoto Pref. for the type and referring the Atsu series to it. There is, however, no fossil common between the Atsu and Arakura formations. The three *Daonella* zones and their ages are as follows:

Daonella yoshimurai zone——Ladino-Carnic Atsu series
Daonella subquadrata zone——Upper Ladinic Zohoin series
Daonella multistriata zone——Lower Ladinic to Upper Anisic Rifu series.

The two species of *Daonella* of the lower zone are related to the North American ones whereas the Tethyan affinity is distinct in the *Daonella* of the middle zone. *D. yoshimurai* is also allied to the Alpine *D. paucicostata.*

Finally, Ussuriland belongs to the same province with Japan, insofar as *Daonella* is concerned. According to KRYSTOFOVICH (1926), it occurs in the Middle Triassic shale at Lianchiho. According to WITTENBURG (1927) the black monotonous shale, 150 m thick, at Lan-tschi-che lies on the tuffaceous marine Permian and is overlain by the Jurassic quartzose sandstone. It yields *Daonella kotoi*, *Daonella sakawana* and *Lingula* sp. Hence the *Daonella* shale is equivalent to the Zohoin series. It is certainly remarkable that this series is isolated from either the older or the younger Triassic formation in Ussuri as in Japan. According to KIPARISOVA (1954) the Ladinic bed of the Maritime Province yields *Daonella densisulcata*, *D.* "*moussoni*" and *Posidonia wengensis* beside *Trachyceras* aff. *furcatum*, *Gymnotoceras* sp. and *Xenodiscus* (*Xenaspis*) aff. *middlemissi*. Her *moussoni* (pl. 18, figs. 5, 6) appears to agree with the *tyrolensis*-group better than the *moussoni*-group, because ribs are regular and distinct through the valve. It may be related to *indica* and allies. The Ladinic, 400 to 800 m thick in the Far East, is

composed mainly of well stratified siltstone to which light coloured quartzose sandstone is added (BELIAEVSKY et al., 1958). The siltstone contains *Daonella densisulcata* and *D. moussoni* abundantly, beside *Protrachyceras*, *Gymnotoceras* and *Ptychites* in rare instances. It can hardly be overlooked that the Ladinic fauna of Ussuri is intimately related to the Rifu and Zohoin faunas in Japan.

In conclusion the authors express their cordial gratitudes to Messrs Kagetoshi HASHIMOTO and Shigeru HIRATA for supply of fossils in their collections.

IV. Note on the Distribution of *Daonella*

A great variety of *Daonella* is known from the Alpine-Tethyan geosyncline, while only 2 species occur from the "Binnensee" facies of the German Trias. These two species* of the Muschelkalk are according to TORNQUIST (1901) related to the Boreal and Californian fauna. In the Ladinic stage limestone and dolomite are extensive in the Alpine facies, whereas clastic sediments are predominant in the Himarayas and South China.

With DIENER and KUTASSY's Catalogues it is known that some 14 Anisic, 35 Ladinic, 3 Carnic and 2 Noric species of *Daonella* occur in the Alps. In the East Alps is the Hallstatt facies whence 19 species of *Posidonia* but only 3 *Daonella* were reported by MOJSISOVICS (1874). All of them were collected from the Carnic and Noric stages. In Aussee region near Salzburg the lower Carnic limestone bears *D. proboscidea* and *D. teltchenensis* beside 15 *Halobia*. *D. imperialis* is coexistent with 13 *Halobia* and 3 *Monotis* in the grey Noric limestone of Ischlana. *Imperialis* and *gosaviensis* are the only Noric *Daonella* in the East Alps. A light grey limestone of the Buchenstein stage in the Seewiesen region near Aflenz yields *moussoni* and its allies. In north Tyrol the Wengen horizon contains *tyrolensis*, *indica* and several other species of *Daonella*.

From the South Alps are reported 8 Anisic, 13 Ladinic and 1 Carnic species. The *Daonella* bed of the Buchenstein stage is represented by the *tarmelii* zone in the upper part where calcareous shales are intercalated in dark or black platy limestones. The *lommeli* bed lies in black or brownish grey sandy platy shale of the lower Wengen stage. The Cassian stage containing *kittli*, is represented by clayey, marly and calcareous sediments in addition to impure limestone and oolite layers.

In Lombardia the *Daonella* bed lies in the upper Esino-limestone which is composed of *lommeli*-bearing platy limestone. SALOMON (1895) described *lommeli*, *esinensis* and *parthanensis* from the Wengen stage of the Marmolata limestone. In south Tyrol several *Daonella* are contained in black marly Muschelkalk of of the Buchenstein stage. The Wengen stage of Wengen is indicated by *lommeli* and 3 *Posidonia*. The Cassian stage yields *kittli*, *richthofeni* and *H. fluxa*.

In Hungaria the Buchenstein stage or the *reitzi* zone is represented by the siliceous yellow limestone with intercalation of marl and contains 4 *Daonella* and 1 *Posidonia*. The Wengen or the *tridentinus* stage contains 10 *Daonella* ubiquitously. It is characterized by hard, red chert-bearing beds, passing upward into light violet marl and chert nodule-bearing light red limestone. Where chert nodule is absent, the red limestone looks like Hallstatt facies and contains cepha-

*) For TORNQUIST's *D. bergeri* KITTL (1912) proposed a new genus *Dipleurites* on the basis of two internal thickenings which run below umbo and are divided posteriorly. According to ICHIKAWA (1958) the thickenings are, however, not original but produced by the secondary modification, and he considers it a synonym of *Daonella*.

lopods. In Balaton lake distirict KITTL (1912) recognized 5 *Daonella* horizons in the Wengen stage above the *tarmelii* zone. They are *pichleri-bulogensis*, *loczyi*, *tripartita-indica*, *lommeli-Posidonia wengensis* and *reticulata* beds in ascending order. Several species of *Daonella* beside *Halobia* occur still higher in brownish limestone of the Cassian equivalent and an additional species of *Daonella* occurs in the white limestone of the Raibl equivalent.

In the Balkan Peninsula 5 *Daonella* are reported from the *lommeli*-zone or the Wengen stage of South Dalmatia where *Daonella* beds are represented by calcareous or sandy shale in tuff and tuffaceous sandstone (ARTHABAR, 1915)-*D.* cfr. *parthanensis* and *D.* cfr. *kittli* are the Cassian elements in the dark shale. In the superjacent formation tuffaceous sediments are replaced by cherty rocks, where *styrica* and others occur. In Bosnia the lower Ladinic stage is built up by red noduliferous limestone, in the middle part of which melaphyre tuff and tuffaceous sandstone containing *lommeli* are intercalated; marl and platy limestone with *pichleri* is found in the upper. Carnic *styrica* is known from the red Hallstatt facies of its middle part. In Greece *kittli* is known in the platy limestone and chert, and *styrica* in the cherty facies (RENZ, 1906). As DIENER (1915) stated, the Alpine Ladinic on the whole is characterized by limestone and dolomite complex.

A few *Daonella* are known from Afganistan and Jordan Valley (COX, 1924). In the Himalaya the Ladinic black limestone with shales yields *lommeli*, *indica* and *spitiensis*.

In Yunnan yellowish or greenish sandstone and shale in alternations are superior to bituminous or muddy limestone. These rocks yield one species of *Daonella* and 4 of *Halobia* besides several other pelecypods and cephalopods. *Daonellae* are known from Kweichow, Kwangsi and Hunan (Compilalation Committee etc., 1958). Light coloured muddy or shaly deposits are developed in west Kweichow and grey limestone, 10–20 m thick in the lower part, yields 3 species of *Daonella*, 4 of *Halobia*, 1 of *Posidonia*, *Protrachyceras* cfr. *archelaus*, other cephalopods, brachiopods and crinoids. In west Kwangsi variegate shales with yellow sandstone and limestone nodules contain 5 species of Anisic *Daonella* beside several other mollusks. They are *moussoni*, *dubia*, *lindströmi*, *elongata* and *producta*, where the last is HSÜ's (1940) new species, closely related to *elongata*. In east Hunan the Ladinic formation is composed of purplish yellow shale, sandstone and light grey limestone in alternation which contain *D. lommeli* and other fossils. Two species of *Daonella* are found from Thailand; one is Carnic *sumatrensis* in the greenish grey clayslate in the tributary of Khlong Mak near Malayan Border and the other an indeterminable form of *Daonella* (ex. gr. *pichleri*) in the clayslate from Lampang.

A *Daonella* bed in Sumatra is composed of clastic sediments and contains *kittli* and *sumatrensis* in shale (VOLZ, 1899). It is equivalent to the Raibl. In Timor *Daonella* is common in the so-called "*Halobia* facies" from Ladinic to Noric (KRUMBECK, 1922), which is composed of limestone, calcaleous shale, clayslate, marly shale, radiolarian-bearing chert and radiolarite (WANNER, 1956). They yield 4 species of *Daonella*, 24 of *Halobia* and 2 of *Monotis* beside some pelecypods and brachiopods. These Ladinic species of *Daonella* are *indica*, *lilintana*, cfr. *bulogensis* and *pichleri* var. *timorensis*. They occur also in the flysch facies composed of light coloured limestone, calcareous or siliceous shale with or without clay matter. Cherty materials are recognized as interstitial deposit as well as bed-forming materials. WANNER (1956) considered them to be auto-

chthonous. The "cephalopod-facies" contains a copious fauna including many upper Ladinic fossils, but *D.* cfr. *bulogensis* is a rare lower Ladinic element. In Portuguese Timor another horizon, probably of the Cassian stage, is represented by *D.* aff. *kittli* and *D. indica* from siliceous limestone. These fossil beds are related to the Hallstatt deposits in fossils as well as lithology, and form Decken. From Rotti, ROTHPLETZ (1892) reported *lommeli* and *kittli* beside 3 species of *Halobia* and a *Monotis*.

In New Zealand exist two *Daonella* beds in south island. One is in the Anisic Etalian stage and the other in the Ladinic Kaihikuan stage. TRECHMANN'S (1917) *indica* from the latter is known now by the name of *apteryx* MARWICK For the *Daonella* beds (1953). in south Ussuri the reader is referred to page 7.

In California and Nevada there are 5 species of *Daonella* beside many ammonites of Middle Trias. According to SMITH (1902) the fauna is related to the Boreal as well as Tethyan fauna but not the Indian one. According to DIENER (1915) and TORNQUIST (1901) the faunas are closer to the Boreal than the Tethyan. Recently ZEIL found the Middle Triassic from Chile, in which *D.* ex gr. *lommelisturi* was included (ICHIKAWA in ZEIL, 1958). This fossiliferous bed is composed of conglomerate, sandstone and shale.

Finally the Anisic "Daonellenkalk" and the Ladinic "Halobienkalk" are known in Spitzbergen. The former is composed of black, marly calcareous shale containing thick limestone lenses and nodules. These black limestones are rich in *D. lindströmi* and *D. arctica* besides 20 ammonites. BÖHM reported *D. loveni* from the Carnic of Bear Island.

Table: *Daonella* from the Zohoin Series

Localties / *Daonella* Species	Zohoin, Sakawa	Okazaki-goe	Ino		Sakuradani Area					
								Usugatani		
			Kuroiwa	Koretomo	Semidani	Junisha	Gorodani	Makiodani	Koyanomizo	Tsuzurazaka
tenuistriata	r	–	–	–	–	–	–	–	–	–
alta	R	–	–	–	–	–	–	–	–	–
indica	c	–	c	c	–	c	r	c	c	c
cfr. *spitiensis*	r	–	–	–	–	–	–	–	–	–
iwayai	r	–	r	–	–	–	–	–	r	c
kotoi	c	–	c	c	r	–	–	–	r	c
kotoi var.	–	–	c	–	–	–	–	–	–	–
sakawana	R	–	r	–	–	–	–	–	–	–
subquadrata	a	?	c	c	–	c	–	c	c	r
subquadrata zohoinensis	a	r	c	c	–	c	–	–	–	–
subquadrata symmetrica	a	–	–	–	–	c	?	c	R	–
pectinoides	r	–	–	–	–	–	–	–	c	–
asymmetrica	r	–	–	–	–	–	–	–	–	–
hiratai	r	–	–	–	r	–	–	–	–	–

a: abundant, c: common, R: rare, r: very rare

It is remarkable that more than 70 forms of *Daonella* are limited to occur in the Alpine-Tethyan geosyncline. Therefore *Daonella* can be said a characteristic pelecypod of the pelagic geosynclinal facies. From the Alpine region approximately 50 forms of *Daonella* are reported. In the Circum-Pacific region, on the other hand, *Daonella* is rather poor and the *Daonella* beds are mostly clastic rather than calcareous. This must be related to the older Mesozoic crustal movement which is known in Japan by the name of Akiyoshi orogeny. It culminated in the Ladinic and Carnic ages. The Alps, where calacareous facies is predominant, was quiet in these ages except a part of the East Alps. Clastic sediments become predominant in the Himalayan and Pacific geosynclines, and cherty facies is often met with in *Daonella* beds in Southeastern Asia.

Both *Daonella* and *Halobia* range from Anisic to Noric, and *Daonella* was flourished in the Ladinic and *Halobia* in the Carnic. The Wengen and Cassian stages are the transition from the *Daonella*-age to the *Halobia*-age. The Buchenstein stage yields more *Posidonia* than *Daonella*. and almost free from *Halobia*. In Himalaya the *lommeli* zone comprises 4 forms of *Daonella* and 3 of *Halobia*. According to Rothpletz *lommli* and *kittli* are coexistent with 3 species of *Halobia* in Rotti. Therefore *Halobia* kept up in the Cassian with *Daonella*. In the Raibl or the *aonoides* zone *Halobia* was already superior to *Daonella*. In Sumatra the *Daonella* bed yields 4 species of *Halobia* and 2 of *Daonella*. In Misol the Ladino-Carnic Keskaïn formation comprises *D. lilintana* and 4 forms of *Halobia*. In the Salzburg Alps 2 lower Carnic forms of *Daonella* and 15 of *Halobia* are coexistent. In Japan *Daonella* and *Halobia* beds are isolated except for the Atsu series, in which *D. yoshimurai* is coexistent with more numerous individuals of *Halobia* in 2 species.

V. Description of *Daonella* in Japan

Genus *Daonella* Mojsisovics

1874: *Daonella* Mojsisovics, *Jb. k. k. geol. R.-A., Bd. 7, Heft 2*, S. 6.

The *Posidonia*-like stage seen in many species of *Daonella* and also *Halobia* in their umbonal regions shows their derivation from *Posidonia* as generally accepted. It is quite probable that *Halobia* was evolved from *Daonella* by the development of the anterior ear, almost simultaneously with the appearance of the latter genus. Their life ranges are from Anisic to Noric, but the acme was Ladinic for the latter and Carnic for the former. This agrees with the frequency of their occurrences in Japan.

Kittl erected *Enteropleura*, *Dipleurites* and *Amonotis* as three new genera of the Halobiidae. In his recent revision Ichikawa (1958) divided the family into the Halobiinae and the Aulacomyellinae (nov.). While he synonymized *Dipleurites* with *Daonella* s. str., he recognized *Enteropleura* as well as *Veldinella* Alma as two subgenera of *Daonella*. As to *Amonotis*, he suggested its possibility to be a member of the latter subfamily.

In 1874 Mojsisovics has classified 26 species of *Daonella* into 3 groups as follows:

1. Gruppe der *Daonella moussoni*: nächst den Schloßrändern keine Rippen.
2. Gruppe der *Daonella tyrolensis*: Rippen nicht gebündelt, bis zu den Schloßrändern reichend.

3. Gruppe der *Daonella lommeli*: Rippen gebündelt.

Later in 1912 KITTL reclassified the genus and 57 species were schematized into 8 groups as follows:

1. Die Gruppe der posidonoiden Formen, die nur eine schwache Radialskulptur besitzen, mit drei Untergruppen;
   a) Untergruppe der *Daonella böckhi*.
   b) Untergruppe der *Daonella proboscidea*.
   c) Untergruppe der *Daonella gosaviensis*.
2. Die Gruppe der *Daonella moussoni* mit schwächerer, oft nur in der Schalenmitte deutlicher Radialskulptur.
3. Die Gruppe der *Daonella tyrolensis* mit deutlichern Radialrippen, welche gewöhnlich eine ein- bis zweimalige Spaltung zeigen und meist bis zu den Schloßrändern reichen.
4. Die Gruppe der *Daonella sturi* und *Daonella lommeli* mit Bündelrippen und von querverlängerter Gestalt.
5. Die Gruppe der *Daonella grabensis* mit feinen, nicht oder undeutlich gebündelten Rippen.
6. Die Gruppe der *Daonella pichleri* mit weit vorgerücktem Wirbel.
7. Die Gruppe der *Daonella lamellosa*, durch vorwiegend konzentrische Skulptur der Schale ausgezeichnet.
8. Isolierte und dubiose Formen.

In the Triassic of Japan there are 14 species of *Daonella*, in addition to 2 subspecies namely, 2 species from the Rifu series, 11 species plus 2 subspecies from the Zohoin series and 1 species from the Atsu series which are classified according to KITTL's scheme as follows:

Group of *moussoni*
- *Daonella atsuensis* KOBAYASHI ..... Atsu Series
- ? *Daonella tenuistriata* KOBAYASHI & TOKUYAMA, n. sp. ..... Zohoin Series

Group of *tyrolensis*
- *Daonella alta* YABE & SHIMIZU ..... Zohoin Series
- *Daonella indica* BITTNER ..... Zohoin Series
- *Daonella* cfr. *spitiensis* BITTNER ..... Zohoin Series
- *Daonella iwayai* KOBAYASHI & TOKUYAMA, n. sp. ..... Zohoin Series
- *Daonella kotoi* MOJSISOVICS ..... Zohoin Series
- *Daonella sakawana* MOJSISOVICS ..... Zohoin Series

Group of *sturi-lommeli*
- *Daonella subquadrata* YABE & SHIMIZU ..... Zohoin Series
- *Daonella subquadrata zohoinensis* KOBAYASHI & TOKUYAMA, n. subsp. ..... Zoeoin Series
- *Daonella subquadrata symmetrica* KOBAYASHI & TOKUYAMA, n. subsp. ..... Zohoin Series
- *Daonella multistriata* YABE & SHIMIZU ..... Rifu Series
- *Daonella densisulcata* YABE & SHIMIZU ..... Rifu Series

Group of *grabensis*
- *Daonella pectinoides* KOBAYASHI & TOKUYAMA, n. sp. ..... Zohoin Series

Group of *pichleri*
- *Daonella asymmetrica* KOBAYASHI & TOKUYAMA, n. sp. ..... Zohoin Series
- *Daonella hiratai* KOBAYASHI & TOKUYAMA, n. sp. ..... Zohoin Series

Group of *D. moussoni*

1. *Daonella yoshimurai* KOBAYASHI

Plate III, figure 2

1935. *D. yoshimurai* KOBAYASHI, *J.J.G.G., Vol. 12*, p. 30, pl. 7, fig. 7.

This species is characterized by semi-circular outline, but broadest shortly

below hinge, subtriangular smooth subhinge area and broad flattopped ribs, 7–10 in number and bifurcated in later stages. Caused by lateral compression, a small left valve (MM 3472) from a point some 150 m SW from the type locality swells up, and is taller than broad; anterior area larger than posterior one.

Comparison:—This is undoubtedly a member of KITTL's *moussoni* group, but no species of the group is very close to it. Ladinic *paucicostata* TORNQUIST differs from it in more prominent umbo, more numerous ribs and narrower posterior subhinge area. Ribs are more numerous and the outline is longer in *udvariensis* KITTL from the Ladinic of Bakony. Finally, Carnic *sumatrensis* VOLZ is similar to it in the wide area, number and more of ribbing, but mode inequilateral.

Occurrence:—Scattered in black shales in the upper Atsu series. At a point north of Shirogawara it is associated with *Halobia atsuensis*, *H. subsedaka* and *Oxytoma atsuense* (TOKUYAMA, 1959) in a shaly bed in the alternation of coarse sandstone and black shale. *Halobia* is more common than *Daonella* in the shales. Here a sandy intercalation yields lower Carnic *Minetrigonia katayamai*.

2. *Daonella tenuistriata* KOBAYASHI and TOKUYAMA, new species

Plate III, figure 10

Description:—Shell almost as high as wide, somewhat diagonal. Hinge line straight, forming obtuse angles at ends. Umbo median, prosogyrous. Ribs numerous, flat-topped, regularly bifurcated in antero-median to postero-median part; median and postero-median ribs often twice bifurcated. Posterior smooth area large. Concentric wrinkles distinct in early stage. In the *Posidonia*-like stage which is relatively long lasting, the shell is prolonged diagonally and wider than high. Then wide and flat-topped ribs appear in the median part which become successively bifurcated. Subsequently this ribbing extends anteriorly. The outline becomes relatively tall and more equilateral in grown stage.

Observation:—A specimen at hand (MM 3473) is an internal mould of open valves, 15.1 mm high and 15.9 mm wide. Ribs are flat-topped in the immature stage. In the anterior part the aspect is maintained until the maturity. Many ribs in the adult stage are bi- or quadri- furcated. Though the posterior part is partly broken, it is certain that it has a large smooth posterior area.

Comparison:—It is related to KITTL's second group in growth change, but in the group ribs are generally weak, often flattopped and rare on the lateral parts. In this species, on the other hand, ribs maintain their significance, though fine, as far as the anterior hinge. Two areas are present, commonly wider in anterior in *moussoni* and *udvariensis*. In the disappearance of posterior ribs this agrees with *pectinoides* but the ribs are simple, round-topped in that species. In once or twice bifurcation of all ribs it resembles *arzelensis* or KITTL's third group, in which, however, the areas are ill-developed and the posterior one is never wider than the anterior one.

Occurrence:—Rare at Zohoin in Sakawa.

Group of *D. tyrolensis*

3. *Daonella alta* YABE and SHIMIZU

Plate I, figures 4, 5

1927. *D. kotoi* var. *alta* YABE & SHIMIZU, *Sci. Rept. Tohoku Imp. Univ. Vol. 11*, p. 122, pl. 12, fig. 10.

Description — Shell subequilateral, somewhat wider than high. Hinge short and rounded at ends. Umbo submedian, prosogyrous. Ribs about 20, flat-topped, wide in median part and narrowing laterally; primary grooves relatively wide and rounded on bottom; secondary grooves starting at about 1 cm from umbo; antero-median ribs sometimes trifurcated; some ribs twice bifurcated in grown stage; posterior ribs sometimes arcuate. Concentric wrinkles fairly distinct near umbo. In *Posidonia*-like stage shell wide and more oblique than in later stages; hinge line relatively long. Then primary ribs suddenly appear in whole breadth.

Observation:—Two specimens of the present collection (MM 3475, 77) agree with the holotype in relatively small size and straight ribs, but the ribs are arcuate in another two larger specimens (MM 3474, 76). They are more or less irregular in the postero-median part in the holotype and also the former two, while in the latter two they are regular (pl. 1, figs. 4, 5). Likewise *D. indica* comprises two forms with straight and arched ribs (BITTNER, 1889, KRUMBECK, 1924). The ratio of width to height varies 1.2–1.5.

Comparison:—This was first considered a high variety of *D. kotoi* but distinct from *kotoi* in the equilateral outline, wide and regular ribs and distinct interspaces. These aspects suggest closer relationship to *tyrolensis* or *indica*. Compared to *tyrolensis* its ribs are somewhat stronger and less numerous.

Occurrence:—Zohoin at Sakawa.

4. *Daonella indica* BITTNER

Plate 1, figures 1, 2; plate 2, figures 1, 2; plate 3, figures 3, 4, 11 & 12; plate 4, figure 1

1899. *D. indica* BITTNER, *Pal. Ind., ser. 15, vol. 3*, p. 39, pl. 7, figs. 4–11.
1907. *D. indica*, WANNER, *N. Jb, Min. usw. 24. B.-Bd.*, p. 202, pl. 9; figs. 8, 9, pl. 10, figs. 2, 3.
1908. *D. indica*, DIENER, *Pal. Indica, ser. 15, vol. 5*, p. 11, pl. 3, figs. 6, 7, 10.
1912. *D. indica*, KITTL, Halobiidae usw., p. 48, pl. 4, figi. 10, 11; pl. 9, fig. 2.
1915. *D. indica*, v.ARTHABER, *Beitr. Geol. Pal. Österr.-Ungarns usw., Bd. 27*, S. 191.
1927. *D. indica*, REED, *Pal. Indica, NS. vol. 10*, p.194, pl. 17, fig. 4.
1930. *D. indica*, KUTASSY, *Földt. Közlöny, Bd. 60*, p. 203, pl. 3, fig. 1.

Description:—Shell rounded, subequilateral, as high as wide. Hinge line short, straight forming obtuse angles with anterior and posterior margins. Umbo median, rounded, slightly projected above hinge. Ribs about 35–50, distinct, flat-topped regularly bifurcated, mostly equal in strength and distributed on whole surface, but become finer near hinge margin. Concentric wrinkles distinct in young. Outline apparently narrower in *Posidonia*-like stage.

Observation and comparison:—In this species ribs are mostly straight, but the median ones are arcuate in two specimens (MM 3478, pl. 1, fig. 2; MM 3492). They are commonly of equal strength and bifurcated regularly on the whole surface, but sometimes become narrower laterally. In another two specimens (MM 3490, 91) a narrow smooth triangular area is seen near the posterior hinge margin. Still another specimens (MM 3495, pl. 1, fig. 1; MM 3539, pl. 3, fig. 4) show irregular trifurcation in the antero-median part.

Daonella indica occurs in Anatolia, Himalaya (BITTNER), Spiti (DIENER), Yunnan (MANSUY), Kweichow (LEE et al.) and Timor region (WANNER, KRUMBECK, KUTASSY) in Asia and the East Alps, Dinaric Alps, Hungaria, and Dalmatia in Europe

(KITTL, ARTHABER). Asiatic specimens bear relatively strong ribs of equal strength on the whole surface as seen on the Himalayan and Timor examples. DIENER's from the *Daonella*-limestone in the west of Lilang also bears fairly distinct straight ribs, but they become weakened toward the hinge. In KITTL's specimen from the Alps they are weaker than in Spiti specimens and become weaker laterally. These European forms resemble *bulogensis* or *tyrolensis*. As above described, Japanese specimens have strong and regular ribs on the margin like the other Asiatic specimens. Compared to the foreign specimens, they are relatively small and bear more ribs. Sakuradani specimens (pl. 3, fig. 3) have numerous and fine ribs, while wide-ribbed (MM 3478, pl. 1, fig. 2) as well as narrow-ribbed (MM 3483) specimens are in Zohoin collection.

In the regular bifurcation *indica* belongs to KITTL's *tyrolensis* group. It agrees with *tyrolensis* MOJSISOVICS, *bulogensis* KITTL, *arzelensis* KITTL's, *lóczyi* KLTTL, *spitiensis* and *lilintana* BOEHM in the tall, equilateral outline and regularly bifurcated ribs. In *indica* most ribs are equal in strength and width and the smooth area near the hinge is either absent or very narrow. The last feature is seen also in Asiatic *spitiensis* and *lilintana*.

Occurrence:—Common through all localities of the Zohoin series in Sakawa, Ino and Sakuradani regions. Sakawa and Sakuradani collections include wide-ribbed and narrow-ribbed forms; most of Ino collection immature. Sakuradani specimens from Junisha, Gorodani and Makiodani, Koyanomizu, Tsuzurazaka in Usugatani, all in the Fujinohira Decke, are deformed by lateral compression in similar manner.

5. *Daonella* cfr. *spitiensis* BITTNER

Plate I, figure 3.

1899. cfr. *D. spitiensis* BITTNER, *Pal. Ind.*, *Ser. 15*, *Vol. 3*, p. 38, pl. 7, fig. 3.

Description:—Shell rounded, eqnilateral, almost as high as wide. Umbo small, median, pointed; hinge short, remarkably rounded at extremities. Ribs about 40, most pronounced at middle, weakened laterally till at last a narrow smooth area appears on each side; median ribs finer on anterior than on posterior side and bifurcated or even trifurcated. Concentric wrinkles distinct in early and middle stage. Young shell relatively high.

Observation and comparison:—An imperfect internal and external mould of a left (?) valve (MM 3496) resemble BITTNER's *spitiensis* closely in the well rounded outline and mode of ribbing, but it is higher and its ribs are more distinct. It is distinguishable from *indica* by its more rounded lateral angles and more developed non-ribbed area.

Occurrence:—Rare at Zohoin in Sakawa.

6. *Daonella iwayai* KOBAYASHI and TOKUYAMA, new species

Plate II, figure 15; plate III, figures 8, 9; plate IV, figure 4.

Description:—Shell a little higher than wide. Hinge line straight, subangular at ends; umbo mesial. Primary furrows about 25, wide and rounded on bottom, while primaly ribs are flat-topped, once or twice bifurcating; secondary ribs in median part provided with 2 or 3 fine tertiary furrows, so that they look like

bundle ribs; tertiary furrows become uncommon toward hinge, but each inserted regularly on a secondary rib in the median part; ribs weakened or effaced near hinge where smooth triagnular areas appear, posterior one being larger than anterior. Concentric wrinkles distinct near umbo.

Observation:—Caused by lateral compression, the holotype (MM 3497) from Tsuzurazaka in Usugatani (pl. 3, fig. 8) is prolonged. Judging from two imperfect specimens from Tosa, the underformed outline of this species may be nearly as wide as high. In the median part of the holotype 2 tertiary furrows are preserved on a secondary rib. In a Zohoin specimen (MM 3498, pl. 2, fig. 15) which is large but fragmentary, furrows of three orders are all rounded on bottom; the primaries about 4 times as wide and as deep as the secondaries, which the latters again are 3 to 4 times as wide and as deep as the tertiaries; a secondary rib bears commonly 2 to 3 tertiary furrows and 4 at maximum. The Kuroiwadani specimen from Ino (MM 3481, pl. 3, fig. 9) which is also large but fragmentary, represents fairly regular twice bifurcation.

Comparison:—In ribbing this is closely related to *bulogensis* KITTL, especially to cfr. *bulogensis* from Timor by KRUMBECK. In this species, however, the primary ribs are never trifurcated as those allies; its outline is higher and more equilateral. In the bundles of ribs the two large imperfect specimens are remarkably similar to *lommeli*, especially to one from Bithynia (ARTHABER, 1915), although the outline is not equilateral and not so high as in this species. *Arzelensis* KITTL from the upper Ladinic Wettersteinkalk of Innsbruck is more or less equilateral and its large form higher than wide. Its outline, position of umbo, hinge extremities and subhinge area accord with those of this species but the ribbing is more regular in this than in KITTL's.

Occurrence:—Common at Tsuzurazaka in Usugatani, Sakuradani in Awa, one specimen is collected from Kuroiwadani near Ino and two more from Zohoin, Tosa. The Holotype collected from Tsuzurazaka.

7. *Daonella kotoi* MOJSISOVICS

Plate II, figures 3–6; plate III, figure 1; plate IV, figures 2, 3.

1888. *D. kotoi* MOJSISOVICS, *Beitr. Österr.-Ungarns usw. Bd. 7*, S. 174, Taf. 2, Fig. 3.
1912. *D. kotoi*, KITTL, Halobiidae usw., S. 74.
1915. *D. kotoi*, ARTHABER, Lethaea Geognostica, II–1, S. 191, Taf. 31, Fig. 1.

Description:—Shell medium to large in size, inequilateral, obliquely ovate and longer than high. Hinge line straight and rounded at ends. Umbo prosogyrous, at about 2/5-length from anterior extremity and acuminate a little above hinge. Primary ribs about 30, distinct flat-topped, becoming narrow and irregular backward; median ribs often bifurcated and rarely trifurcated; concentric wrinkless more or less distinct. Three stages of growth can be distinguished as follows:

1. *Posidonia*-like stage: smaller than 3 mm long and 2.5 mm high (MM 3489, pl. 2, fig. 6; 3549), round, convex, with concentric growth lines and without radial markings.
2. *Moussoni*-like stage (MM 3489, pl. 2, fig. 6): about 3–7.5 mm long 2.5–5 mm high, roundly ovate; several narrow and weak radial grooves start at first in median part, successively added on posterior side; ribs narrower in posterior than median part.

3. Adult stage: shell 5 cm long and 3 cm high at the maximum (pl. 2, fig. 3, holotype, MM 5001), longer than high and more diagonally elongated than in young stages; ribs cover whole surface, uniform in strength, of same width in antero-median part and slightly narrow on posterior side, where secondary grooves are absent or 2 secondaries are inserted on a primary rib. They start at first in the median part (MM 3489, pl. 2, fig. 6), occur in anterior in the next and finally on the posterior side.

Observation:—The outline is variable in this species to some extent. Length/height ratio and obliquity are commonly greater in some Zohoin specimens than the holotype. The beak happens to be submedian on hinge (MM 3503, pl. 3, fig. 1). The mode of ribbing is variable. In some specimens (MM 3488, pl. 2 fig. 5) secondary grooves are indiscernible in the antero-median part as in the holotype, but distinct in others. The ribbing is fairly regular in some but in some others it is irregular in strength and width in posterior.

Comparison:—Mojsisovics included this species in the *tyrolensis* group, while did Kittl in the *sturi-lommeli* group. In the simple ribbing it may be included in the former group. However, if its growth change is considered, it is related to the *moussoni* group. *Daonella paucicostata* Tornquist from the Ladinic of the South Alps and Dinaric Alps is close to it. In the growth change, ribbing and antero-dorsal aspect *paucicostata* fits in it. Mojsisovics' is, however, a little more oblique and ribs are more or less stronger than Tornquist's. *D. apteryx* Marwick from New Zealand is another close ally, but has more ribs. In outline and ribbing this species resembles *D. kittli* Krumbeck from the Carnic of St. Cassian, which, however, is distinguishable from it by the second growth stage when, according to Kittl, grooves start at once in the entire shell in *kittli*, while in this they start at first in the median part.

Occurrence:—Common in Zohoin and Ino in Tosa and Tsuzurazaka in Sakuradani regions, but rare in Semidani. At Koretomo and sometimes at Sakawa small shells are crowded.

Daonella kotoi Mojsisovics var.

Plate II, figure 7

Description:—Shell more or less obliquely elongated; anterior angle of hinge line subrounded; umbo in anterior or hinge line prosogyrous, Ribs wide, flat-topped, sometimes flexiated, appearing first in median part, regularly trifurcated there and bifurcated on sides. Concentric wrinkles present in umbonal region.

Observation and comparison:—Three specimens at hand (MM 3507/1–3) are all imperfect. In the oblique outline and regular trifurcation of the median ribs this form resembles Bittner's cfr. *indica* from Pin valley in Spiti (1889, pl. 7, fig. 12), which was referred to cfr. *bulogensis* Krumbeck, although its trifucation is more regular. Among Japanese species *kotoi* is most intimate to this, except for the regularity of trifurcation.

Occurrence:—Not rare at Kuroiwa, near Ino, Tosa.

8. *Daonella sakawana* Mojsisovics

Plate II, figure 8.

1888. *D. sakawana* Mojsisovics, *Beitr. Pal. Österr.-Ungarns usw., Bd. 7*, S. 174, Taf. 2, Fig. 4 (non Fig. 5).

1912: *D. sakawana*, KITTL, Halobiidae usw., S. 74.

Description:—Shell medium in size, inequilateral, obliquely ovate, wider than high. Umbo prosogyrous, pointed above hinge at anterior 2/5; hinge straight, relatively short, forming an obtuse angle with anterior margin. Ribs about 40, distinct, regular, flat-topped, usually bifurcated, uniform in width in median part, narrowing towards hinge; in antero-median part a fairly stronger groove inserted in every 3 or 4 primary ribs. Concentric wrinkles fairly distinct, closely spaced in earlier stage and widely later. Outline high and less inequilateral at the beginning, becoming relatively low and more obliquely elongated. In consequence adult shells look more inequilateral than young ones.

Observation:—MOJSISOVICS' type specimens include 2 species. One (pl. 2, fig. 9, MM 5003) is specifically distinct from the other in fig. 4 (pl. 2, fig. 3, MM 5002) and belongs probably to *subquadrata zohoinensis*. A few fragmentary specimens in the present collection are identifiable with this species.

Comparison:—Originally, MOJSISOVICS included this species in his *tyrolensis* group, while KITTL referred it to his group of *sturi-lommeli*. The regular bifurcation of ribs on the whole surface suggests its being a member of the *tyrolensis* group, Cassian *kittli* KRUMBECK and *richthofeni* by BITTNER (1895) are especially similar to but different from it in the second growth stage, in which they have ribs on the entire surface, because in this species ribs appear only in the median part. In other words it grows through *moussoni*-like stage as *kotoi*. It differs from *kotoi* in its denser and more regular ribs. The anterior end of the hinge is rounded in *kotoi*, but angled in this; ribs are more or less rounded in it but flat-topped in *kotoi*.

Occurrence:—Relatively rare at Zohoin, Sakawa and at Kuroiwadani, Ino.

Group of *D. sturi-lommeli*

9. *Daonella subquadrata* YABE and SHIMIZU

1915. *D. sakawana*, DIENER, *Denkschr. k. Akad. Wiss., Wien, Bd. 92*, S. 25, Taf. 1, Fig., 3; Taf. 2, Fig. 5.

1927. *D. densisulcata* var. *subquadrata* YABE & SHIMIZU, *Sci. Rept. Tohoku Imp. Univ. Sec. 2, Vol. 11*, p. 122, pl. 22, fig. 9.

Description:—Shell large; outline considerably variable from obliquely elongated, highly inequilateral, to high, equilateral form. Umbo median or a little anterior, sharp, obtusely angled at anterior end but rounded at posterior end. Ribs fine, about 60, round-topped, distributed on whole surface, wider in posterior than anterior side, regularly bifurcated in anterior and antero-median parts, trifurcated in median part and irregularly trifurcated in posterior. Concentric wrinkles fairly distinct. In *Posidonia*-like stage (MM 3553; 3514, pl. 3, fig. 5), shell diagonally ovate, wider than high, with prominent, large and prosogyrous umbo; in the succeeding stage (pl. 2, fig. 10), flat-topped simple ribs start in anterior and median parts and suddenly bifurcated; ribbing successively extended over whole breadth; simultaneously, outline becomes subquadrate or trapezoidal. Then shell growth diverges in three trends; outline elongated diagonally and tending more inequilateral in one; shell becomes taller and almost equilateral in another; still another form to which the holotype belongs, is intermediate. Here are recognized the following 2 subspecies beside the typical form:

a) *Daonella subquadrata zohoinensis* KOBAYASHI and TOKUYAMA, new subspecies.

Plate I, figures 12, 13; plate II, figure 9; plate III, figure 5.

Shell ovate or subelliptical, diagonally elongated, strongly inequilateral. Umbo at anterior 1/3 to 2/5 of hinge. Sometimes shell more elongated posteriorly than diagonally (MM 3511, pl. 1, fig. 13; MM 3512, 13), but some others has the prolonged postero-median part (MM 3510, pl. 1, fig. 12). Shell is usually wider than high.

b) *Daonella subquadrata* YABE & SHIMIZU (s. str.)

Plate I, figures 6, 7; plate II, figures 9, 10.

Shell roundly ovate, almost as high as wide. This is suboval and wider than high in *Posidonia*-stage (MM 3518), but trapezoidal or subquadrate in later stages (MM 3521, 23, 24). Finally, it tends to be prolonged postero-ventrally (MM 3516, pl. 2, fig. 6).

c) *Daonella subquadrata symmetrica* KOBAYASHI & TOKUYAMA, new subspecies

Plate I. figures 8–11.

Shell equilateral, higher than wide. This also grows through the suboval and subquadrate stages but short and the outline is high already in immature stages. Subsequently the height increase greatly.

Observation:—The large shells are often met with in typical *subquadrata* (pl. 1, fig. 6). Strength and density of ribs are almost same through the surface. In the full-grown examples (MM 3510, 16.) bi- or tri-furcated ribs are again bifurcated (pl. 1, figs. 6, 12). In case of tri-furcation ribs are sometimes divided so unequally that a secondary rib happens almost twice as wide and as strong as another. Grooves on the bundled ribs are narrower than every secondary rib. The bundles in this species are produced regularly by bi- and tri-furcation in later stages, whereas ribs of KITTL's 4th group such as of *sturi*, *lommeli* etc. are "bundle-ribs" already at the beginning.

Comparison:—This was originally described by YABE and SHIMIZU as a variety of *densistriata* from the Rifu formation. *Densistriata*, however, widely differs from this in outline and mode of ribbing. Namely, *densistriata* is more or less convex and much wider than high; the ratio of width/height is smaller in early stage and becoming larger through growth, while the growth change is reverse in *symmetrica*. The ribs in *densistriata* are flat-topped, widest in the median part, and narrow laterally, especially posteriorly; but in this species they are round-topped, uniform in width and strength, and regularly bi- or trifurcated.

Daonella lilintana BOEHM from west Misol is the closest ally to this species, especially to *symmetrica*. This subspecies is identifiable with *lilintana*, if irregular bifurcation of ribs in *lilintana* are ignored. In KRUMBECK's *lilintana* from Keskaïn island, ribs are generally weak, widest at the median part, a little narrow and obscure toward the hinge till a narrow triangular smooth area is formed. If *lilintana* of the two islands can safely be identified, *symmetrica* is separable from *lilintana* in the specific rank. This and *lilintana* belong to the same group with *indica* (KITTL, 1912). In KITTL's 4th group some species have no typical bundle-rib of *sturi*, for example, *longovarica* KITTL or *gaderana* KITTL. They resemble this in ribbing, but differ in the smooth area near the hinge.

Occurrence:—Abundant in the Zohoin series. *Subquadrata* (s. s.), *zohoinensis* and *symmetrica* are all well represented in the Zohoin collection. Poor impressions of *subquadrata* occur at Okazakigoe. Kuroiwadani collection includes many *zohoinensis* and several *quadrata*, but no *symmetrica*, while in the Sakuradani collection *symmetrica* is common and *zohoinensis* is absent except at Naise in Junisha.

10. *Daonella multistriata* YABE and SHIMIZU

Plate III, figure 7.

1927. *Daonella kotoi* MOJSISOVICS var. *multistriata* YABE & SHIMIZU, *Sci. Rept. Tohoku Imp. Univ., Ser. 2, Vol. 11, No. 2*, p. 123, pl. 11, figs. 12, 13.

This is specifically distinct from *kotoi*. It is related closer to *americana* SMITH or *dubia* GABB than *kotoi*, because *kotoi* belongs to KITTL's *tyrolensis* group, but this is a member of the *sturi-lommeli* group, to which *americana* and *dubia* also belong. In *multistriata* ribs in the median part are wide, flat-topped and irregular, but become weak laterally; fine ribs in postero-ventral to posterior side effaced in distinct triangular subhinge area; anterior ribs a little stouter and more distinct than posterior ones. *Kotoi* is characterized by ribs which are flat-topped, fairly regular, bifurcated, approximately of the same width from anterior to postero-ventral part; moreover the triangular smooth subhinge area is absent in *kotoi*.

Occurrence:—Rifu.

11. *Daonella densisulcata* YABE and SHIMIZU

1927. *Daonella densisulcata* YABE and SHIMIZU, *Sci. Rept. Tohoku Imp. Univ. Vol.* 11, No. 2, p. 125, pl. 11, fig. 13. (non pl. 12, figs. 8, 9)

1954. cfr. *D. densisulcata*, KIPARISOVA, Field illustrated Atlas etc. p. 27, pl. 18, figs. 7, 8.

Daonella densisulcata is closely allied to "*moussoni*" by SMITH though different from typical *moussooi* from the Alps, because ribs are distinct, more or less irregular and sometimes flexiated in this and SMITH's, while, they are weaker, simpler and regular in typical *moussoni*. Nevertheless, these three forms agree in more or less diagonally elongated outline and fairly wide, smooth, triangular subhinge area. YABE and SHIMIZU's specimen from Zohoin in pl. 12, figs. 8, 9 belong to *subquadrata*, from which it is distinct in its bundled ribs and fairly wide smooth subhinge area.

One of KIPARISOVA's (1954) *densisulcata* (fig. 8) bears more regular ribs and narrower flattened subhinge-area than the typical Rifu form. The other specimen (fig. 7) is more closely related to the *subquadrata*-group, because ribs are distinct through the surface and they are almost regularly quadrifurcated. Further, its outline is higher and less oblique than *densisulcata*.

Occurrence:—Rifu.

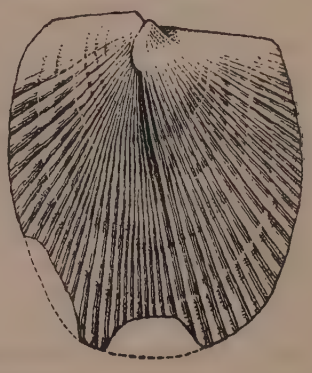
Group of *grabensis*

12. *Daonella pectinoides* KOBAYASHI and TOKUYAMA, new species

Plate II, figure 12; plate III, figure 6, Text-figure

Description:—Shell small, tall and equilateral. Hinge line longs, traight and subrectangular at extremities. Umbo small, bifurcated, round-topped,

widest in antero-median part; interspaces wide in anterior and narrow in anterodorsal; anterior triangular subhinge area fairly wide and non-ribbed, but marked with distinct concentric wrinkles. Juvenile shell fairly convex, equilateral, as high as wide, devoid of radial markings. In the second stage, ribs appear in median part, and then on lateral sides; outline sub-equilateral and as high as wide. In the third stage shell elongated posteroventrally and becoming higher than wide. Adult outline again equilatelal.



Text-figure: *Daonella pectinoides;* a diagonally compressed specimen showing the two manners of deformation.

Observation and comparison:—The holotype (MM 3532) is right internal mould, 13.2 mm. high and 11 mm wide. This spacies is related to the KITTL's 5th group. For example, *zellensis* KITTL from the Anisic of the North Alps and *subtenuis* KITTL from the Anisic of Bakony agree with it in shape, strength and density of ribs and width of posterior smooth subhinge area. It is, however, distinguishable from them by its high and equilateral outline.

Secondary deformation:—The junior author made an interpretation to the deformation of a laterally compressed left valve, MM 3533, from Usugatani in Sakuradani (pl. 3, fig. 6; Text-fig.). It is semielliptical and higher than wide; hinge line straight, subrectangular and rounded at extremities; ribs about 40, distinct simple, rounded on top and a few bifurcated. Its triangular, smooth and non-ribbed subhinge areas are narrower than in the holotype. Two kinds of deformation were produced on this specimen by the same stress from antero-dorsal to postero-ventral. The anterior part was deformed in harmony with surrounding medium of rock matrix, whereas the posterior part did not harmonize. Due to the compression rectangular to the stress its ribs were most narrowed in the antero-ventral part, while in the posterior part the ribs were modified not so much as between the hinge and ventral side. In non-deformed specimens, however, ribs are widest in the antero-dorsal part.

When stress operates a plastic body, it will be compressed in the trend of stress, but expanded rectangularly in case of equi-volume deformation. Therefore volume change is small or none in the anterior part of the shell. In another case, the deformation with volume change, the plastic body is simply compressed without rectangular expansion, as seen in posterior part of the shell, while the anterior part was probably deformed in the former manner at the beginning but later by the latter manner. In consequence the anterior part became longer than the posterior; in the former the density of ribs is considerably reduced near the hinge and in the ventral side, while the reduction is not so great in the latter. The median crack and the angle between the anterior and posterior hinge line show the difference between the two manners of deformation under the diagonal stress. It suggests that the compaction was incomplete when stressed.

Occurrence:—Rare at Zohoin in Sakawa and common at Tsuzurazaka and Makiodani in Usugatani in the Sakuradani region.

Group of *pichleri*

13. *Daonella asymmetrica* KOBAYASHI and TOKUYAMA, new species

Plate II, figure 13

Description:—Shell small, roundly trapezoidal, diagonally elongated, widest shortly below hinge and nearly twice as long as high. Anterior and hinge margins form acute angle; antero-ventral margin rounded, passing into posterior one; posterior and postero-dorsal margins rounded. Beak prosogyrous, pointed above hinge at anterior third. Ribs about 30, stout, simple, rounded and widest in antero-median part, where interspaces are also wide, and finer in posterior than anterior side. Non-ribbed smooth triangular areas wider in posterior than anterior. Concentric wrinkles widely spaced. Smooth juvenalium relatively higher and prosogyr, followed by the stage of ribbed posterior and then wholly ribbed stage.

Observation and comparison:—A left internal mould, MM 3534, is 18.6 mm. long and 10.5 mm high. According to KITTL (1912) *D. pichleri* comprises specimens of various outlines. Among them a young specimen from Bosnia in fig. 5 on pl. 4 is the closest ally to this. The posterior extremity in the *pichleri*, however, is sharp and lies just below the hinge line, while in this it lies more ventrally and well-rounded; ribs are coarser and stouter in this than in *pichleri*.

Occurrence:—Rare at Zohoin in Sakawa.

14. *Daonella hiratai* KOBAYASHI and TOKUYAMA, new species

Plate 2, figure 14.

Description:—Shell small, crescentic but dilating backward, 2–3 times as wide as high. Umbo prosogyrous, pointed at anterior fifth of long, straight hinge line. Ribs about 30, simple, round-topped covering antero-median to posterior surface, strongest in postero-median part, weakened anteriorly and effaced in anterior third. Concentric wrinkles distinct, closely spaced in anterior and umbonal region, becoming weaker and widely spaced in posterior. This shows posteriorly accelerated growth in the middle stage.

Observation:—An internal and external mould of open bivalved specimen (MM 3535) is 16 mm long, 6.5 mm high and depressed diagonally. Its original outline may be semi-oval or obliquely crescentic. Due to depression ribs are weakened on the anterior half. Therefore the true width of the anterior smooth area is indeterminable, although it is evident that the ribs are distinct in the posterior part but weakened forward.

Comparison:—In the umbonal position and the mode of ribbing it belongs undoubtedly to the KITTL's 6th group. In outline and ornaments it resembles *D. pichleri* MOJSISOVICS and *D. pauri* KITTL, both from Bukowina, Austria, but none has so wide anterior smooth area, anteriorly allocated umbo and so large width/height ratio and finer and more ribs. Finally, *D. sumatrensis* is the closest ally to this, but distinguishable from this by its smaller width/height ratio.

Occurrence:—One specimen each from Zohoin in Sakawa and Semidani in the western extremity of the Fujinohira-Decke in the Sakuradani region in Awa.

VI. A Supplementary Note on *Halobia* in Japan

KOBAYASHI and ICHIKAWA (1949) proposed a new name, *Halobia aotii*, for

H. multistriata KOBAYASHI and AOTI (1943), because the latter was found to be duplicated by *Halobia kwaluana* var. *multistriata* VOLZ, 1899. Simultaneously, they instituted a new species, *Halobia kashiwaiensis*, for a form from the *Oxytoma-Mytilus* sandstone at Kashiwai in Sakawa basin, Kochi Pref. Later ICHIKAWA (1954 b) reported the occurrences of *H. kawadai* and *H. obsoleta* at several localities in the Sakuradani-Kito area, Tokushima Pref. and *H. molukkana*, *H.* aff. *austriaca* and *Halobia* sp. at Iwai near Itsukaichi, Tokyo Pref. (1954 a). Subsequently, NAKAZAWA (1955) described from the Nabae formation in Kyoto and Fukui Prefectures, *Halobia kawadai*, *H. obsoleta*, *H.* cfr. *aotii* and *H.* cfr. *austriaca* beside 3 indeterminable forms of the genus. Recently TAMURA (1958) reported *H. kawadai* and *H. molukkana* from Matsukuma in the Kuma region in central Kyushu.

In Nagato *Halobia* occurs in three beds. The oldest is *Daonella* bed in the Atsu series whence the junior author (1959) described 2 new species, *Halobia atsuensis* and *H. subsedaka*. The second is the Hirabara formation of the Mine series which contains *kashiwaiensis* and *kawadai* in two horizons. The third is the Aisaka-Okibe bed or the *aotii* bed, in which *kawadai* was also collected recently. *Aotii* occurs further in the upper Nakatsuka formation (TOKUYAMA, 1959).

Thus, 5 leading species of *Halobia* are in ascending order, namely, *atsuensis*, *kashiwaiensis*, *kawadai*, *aotii* and *obsoleta*. This succession is applicable to the Kochigatani, Nabae and Nagato faunas, although they are not quite distinct as zone species. They are commonly found together in the Kuma and Sakuradani faunas. As a general tendency the more off-shore the sediment, the less the facies variability. Therefore the "*Halobia* beds" look explicit in the Mine and Nabae formations on the continental side, but become obscure in Sakuradani and Kuma areas on the Pacific side. The number of zones and their distinctiveness match with the Carnic palaeogeography of West Japan in the following manner:

(1) 3 *Halobia* zones in the Atsu, Mine and Asa areas and Nabae formations of the intra-orogenic zone.

(2) 2 *Halobia* zones in the Kachigatani series of the Sakawa basin in the inner side of the peri-orogenic zone.

(3) No distinct *Halobia* zone in the Kochigatani series in the Kuma and Sakuradani areas in the outer side of the peri-orogenic zone, although the genus is a common member of the Kochigatani fauna of the areas.

(4) *Halobia* occurs rarely in the Sambosan limestone in the extra-orogenic zone.

References Cited

V. ARTHABER, G. (1915): Die Trias von Bithynien (Anatolien). *Beitr. Pal. u. Geol. Österr.-Ungarns usw., Bd. 27*, S. 85–206, Taf. 9–18.

BANDO, Y. (1958): On the Discovery and its Meaning of *Protrachyceras* from the Rifu Formation in the Kitakami Massif, Northeastern Japan, *J. Geol. Soc. Japan, Vol. 64*, pp. 348–349.

BELIAEVSKY, N. A. et al. (1958): Geologic Structure of U.S.S.R. Vol. I.

BITTNER, A. (1895): Lamellibranchiaten der alpinen Trias. 1. Teil: Revision der Lamellibranchiaten von Set. Cassian. *Abh. k. k. geol. R.-A., 18. Bd.* 235 S., 24 Taf.

——— (1899): Brachiopoda and Lamellibranchiata. *Pal. Ind., ser. 15, Vol. 3, Pt. 2.* pp. 1–76, pls. 1–12.

——— (1901): Lamellibranchiaten aus der Trias Bakonyerwaldes. *Result. wiss. Erf. Balatonsees, I/1, Pal. Bd. 1*, S. 1–106, Taf. 1–9.

Compilation Comittee for Geology of China & Geological Institute, Academia Sinica (1956, 58): Tables of Geological Sequenses in China and its Supplement.

COX, L. R. (1924): A Triassic fauna from the Jordan Valley. *Ann. Mag. Nat. Hist. Ser. 9, Vol. 14*, pp. 52–96, pls. 1, 2.

DIENER, C. (1908): Ladinic, Carnic and Noric Faunae of Spiti. *Pal. Ind., Ser. 15. Vol. 3, No. 3*, pp. 1–157, pls. 1–24.

——— (1912): The Geology of the Himalayas. *Mem. Geol. Surv. India, Vol. 36, Pt. 3*, pp. 202–306.

——— (1915a): Japanische Trias Faunen. *Denkschr. k. k. Akad. wiss. Wien, 92. Bd.*, S. 1–30, Taf. 1–7.

——— (1915b): Die marinen Reiche der Triasperiode. *Ibid.*, S. 407–549, I Taf.

——— (1923): Lamellibranchia triadica. *Foss. Catalogus I, Pars 19*, 225 S.

FRECH, F. et al. (1903–08): Lethaea geognostica, II. Teil Das Mesozoicum, 1. Bd. Die Trias. *Stuttgart*, 623 S. 68 Taf.

GRUNAU, H. R. (1953): Geologie von Portugiesisch Osttimor. *Ecl. Geol. Helv. Bd.46, Nr. 1*, S.29-37.

HIRATA, M. (1950): Geology of the Eastern Part of Monobegawa Basin, Kochi Pref. *Nature and Culture (Shizen to Jinbun) Vol. 1*, p. 81–92.

HSÜ, T. Y. (1940): On the Occurrence of Anisic Fauna in the Tunglan District, Kwangsi. *Bull. Geol. Soc. China, Vol. 20*.

ICHIKAWA, K. (1954a): Early Neo-Triassic Pelecypods from Iwai, near Itsukaichi, Tokyo Pref. *Japan. J. Geol. Geogr., Vol. 25*, pp. 177–195, pl. 17.

——— (1954b): Late Triassic Pelecypods from the Kochigatani Group in the Sakuradani and Kito Areas, Tokushima Pref., Shikoku, Japan, Pt. 1. *J. Inst. Polytechn. Osaka City Univ., Vol. 1, No. 1*, pp. 35–55, pls. 1, 2.

——— (1958): Zur Taxionomie und Phylogenie der Triadischen "Pteriidae" (Lamellibranch.), mit besonderer Berücksichtigung der Gattungen *Claraia, Eumorphotis, Oxytoma* und *Monotis. Palaeontogr. Bd. 111, Abt. A*, S. 131–214, Taf. 21–24.

KIPARISOVA, L. D. (1954): Field Illustrated Atlas of characteristic Floras and Faunas of Triassic Period, Maritime Prov.

KOBAYASHI, T. (1931a): Note on a new Occurrence of Ladino-Carnic Limestone at Sambosan, Tosa Province, Japan. *Japan. J. Geol. Geogr. Vol. 38*, pp. 251–258.

——— (1931b): On the Triassic Formation and two "Klippen" of Palaeozoic Rocks in Sakawa Basin, Pt. 2. *J. Geol. Soc. Tokyo, Vol. 38*, pp. 361–380.

——— (1935): Einige neue triadische Bivalven aus der Innenzone Südwest-japans. *Japan. J. Geol. Ceorgr. Vol. 12*, pp. 27–32, pl. 7.

——— (1941): The Sakawa Orogenic Cycle and its Bearing on the Origin of the Japanese Island. *J. Fac. Sci., Imp. Univ. Tokyo, Sec. 2, Vol. 5, Pt. 7*, pp. 219–578.

——— et al. (1951): Triassic Stratigraphy of Japan. *Rept. Spec. No., Geol. Surv. Japan.*

——— & AOTI, K, (1943): *Halobiae* in Nippon. *J. Sigen Ken. Vol. 1, No. 2*, pp. 241–255, pls. 24, 25.

——— & ICHIKAWA, K. (1949): *Myophoria* and other Upper Triassic Pelecypods from the Sakawa Basin in Shikoku, Japan. *Japan. J. Geol. Geogr. Vol. 21*, pp. 177–187, pl. 6.

——— & IWAYA, Y. (1941): On the Imbricated Structure of the Sakuradani Area in the Prov. of Awa. *Proc. Imp. Acad. Tokyo, Vol. 17*, pp. 110–115.

KRUMBECK, L. (1922, 24): Die Brachiopoden, Lamellibranchiaten und Gastropoden der Trias von Timor, 2 Teilen. *Pal. Timor, Lief. 10, Bd. 17*, S. 1–142, 7 Taf.; *Lief. 13, Bd. 22*, S. 143–417, Taf. 179–198.

KRYSCHTOFOVICH, A. (1926): Geology in "the Pacific". Russian Scientific Investigations, pp. 48–64.

KUTASSY, A. (1930): Triadische Fossilien von portugiesischen Timor. *Föld. Közlöny, Bd. 90*, S. 200–209, 1. Taf.

——— (1931): Lamellibranchiata triadica. *Foss. Catalogus, I. Pars, 51*, S. 261–477.

MANSUY, H. (1921): Description de quelques espèces de l'ouralo-permien et du Trias du Tonkin occidental. *Mém. Surv. Géol. Indochine. Vol. 8, Fasc. 1.*

MARWICK, J. (1953): Divisions and Faunas of the Hokonui System (Triassic and Jurassic). *N. Z. Geol. Surv., Pal. Bull, No. 21*, 141 pp. 17 pls.

v. MOJSISOVICS, E. (1874): Über die triadischen Pelecypodengattungen *Daonella* und *Halobia*. Abh. Geol-R. A. 7/2, S. 1–37, Taf. 1–5.

——— (1888): Über einige japanische Trias-Fossilien. *Beitr. Pal. Geol. Österr.-Ungarns* usw. *Bd.* 7, S. 163–176, Taf. 1–4.

MULLER, S. W. & FERGUSON, H. G. (1939): Mesozoic Stratigraphy of the Hawthorne and Tonopha Quadrangles, Nevada. *Bull. G. S. A., Vol 50*, pp. 1573–1624.

NAKAZAWA, K. (1955): A Study on the Pelecypod Fauna of the Upper Triassic Nabae Group in the Northern Part of Kyoto Pref., Japan. Pt. 3: Halobiids and others. *Mem. Col. Sci. Univ. Kyoto, Ser. B, Vol. 22, No. 2*, pp. 243–260, pls. 13–16.

——— (1957): On the discovery of *Monophyllites* from the Maizuru Zone and its Meaning. *Chikyu Kagaku, Vol. 35*, pp. 39–40.

——— (1958): Arakura Formation and Arakura Age (A Study on the Stratigraphy and Geologic Structure of the "Maizuru Zone", Pt. 7). *Ibid, No. 36*, pp. 19–21.

NEWTON, R. B. (1925): On marine Triassic Fossils from the Malayan Provinces of Kedah and Perak. *Geol-Mag. Vol. 68, No. 728.*

OGILVIE GORDON, M. M, (1927): Das Grödner-, Fassa- and Enneberggebiet in den Südtiroler Dolomiten. 3 Teilen, *Abh. geol. B.-A., Bd. 24, Heft 1, 2.*

——— (1929): Geologie des Gebietes von Pieve (Buchenstein) St. Cassian und Cortina d'Ampezzo. *Jb. Geol. B.-A. Bd. 79*, S. 357-424, Taf. 8–11.

PHILIPP, H. (1904): Paläontologisch-geologische Untersuchung aus dem Gebiet von Predazzo. *Z. Deutsch, Geol. Ges. 56. Bd.*, S. 1–98, Taf. 1–6.

RENZ, C. (1906a): Trias und Jura in der Argolio. *Ibid. 58. Bd.*, S. 379–95, Taf. 19.

——— (1906b): Über Holobien und Danollen aus Griechenland nebst asiatischen Vergleichsstücken. *N. Jb. Min., Jg. 1906/I*, S. 27–40, Taf. 3.

REED, F. R. C, (1927): Palaeozoic and Mesozoic Fossils from Yun-nan. *Pal. Ind. NS, Vol. 10, No. 1*, 291 pp. 20 pls.

ROTHPLEZ, A. (1892): Die Perm-, Trias- und Juraformation aus Timor und Rotti. *Palaeontogr. Bd. 39*, S. 57–106, Taf. 6–14.

SALOMON, W. (1895): Geologische und Palaeontologische Studien über die Marmolata. *Ibid, Bd. 42*, S. 1–210, Taf. 1–8.

SHINOHARA, I. (1941): New Localities of Triassic Fossils in Naka-gun, Awa. *J. Geol. Soc. Japan, Vol. 48*, p. 52 (Short Note).

——— (1946): On the *Daonella* and *Halobia* beds near Tenkaisan, Prov. Awa. *Ibid. Vol. 52*, p. 8, (Misc. Note).

SMITH, J. P. (1902): Ueber Pelcypodenzonen in der Trias Nordamerikas. *Zbl. f. Min. Jg. 1902*, p. 685–695.

——— (1914): The Middle Triassic invertebrate faunas of North America. *U. S. G. S. Prof. Pap. 83.*

STOLLEY, E. (1911): Zur Kenntnis der arktischen Trias. *N. Jb. Min. Jg. 1911/I*, S. 114–123, Taf. 9.

SUYARI, K. in YAMASHITA, SUYARI, NAKAGAWA & HIRAYAMA. (1957): Geol. Map of Tomioka and Hiwasa districts, Tokushima Pref. and its Exp. Text. 24 pp. Tokushima Pref.

TAMURA, M. (1958): Carnic Pelecypods from Matsukuma in Central Kyushu, Japan. *Mem. Fac. Edc. Kumamoto Univ., Vol. 7*, pp. 219–224, pl. 2.

TOKUYAMA, A. (1957): On the late Triassic Rhynchonellids of Japan. *Japan. J. Geol. Geogr. Vol. 28*, pp. 121–137, pls. 10, 11.

——— (1959): Late Triassic Pteriacea from the Atsu and Mine Series, West of Japan. *Ibid. Vol. 30*, pp. 1–19, pl. 1.

——— (1958): Die obertriadische Molasse im Mine-Gebiet Westjapans. *J. Geol. Soc. Japan. Vol. 46, Nos. 756, 757.*

TORNQUIST, A. (1903): Die Daonellen des deutschen Muschelkalkes. *N. Jb. Min. Jg. 1902/II*, S. 83–92, Taf. 1.

TRECHMANN, C. T. (1918): The Trias of New Zealand. *Q. J. G. S. London, Vol. 73*, pp. 165–246, 9 pls.

VOLZ, W. (1899): Beiträge zur geologischen Kenntnis von Nordsumatra. *Z. Deutsch. Geol. Ges. 51. Bd.*, S. 27–36.

WANNER, J. (1907): Triaspetrefakten der Molukken und des Timorarchipels, Geologische Mitteilungen aus dem Indo-Austrarischen Archipel, IV. *N. Jb. Min. usw. 24. B.-Bd.* S. 161–220.

——— (1931) Mesozoicum in Feestbundel K. MARTIN: Leiden, *Leid. Geol. Meded.* pp. 567–608.

——— (1956): Zur Stratigraphie von Portugiesisch Timor. *Z. Deutsch. Geol. Ges. 108. Bd. 1. Teil*, S. 109–140, Taf. 3, 4.

WITTENBURG, P. (1927): Zur Kenntnis der Triasablagerungen des Süd-Ussuri-Gebiete, *Cbl. Min. usw. Jg. 1927*, S. 497–504. *Abt B.*

YABE, H. and SHIMIZU, S. (1927): *Daonella* Beds of Rifu near Sendai. *Proc. Imp. Acad. Tokyo, Vol. 3, No. 5*, pp. 361–363.

——— & ——— (1927): The Triassic Fauna of Rifu, near Sendai. *Sci. Rept. Tohoku Imp. Univ., Ser. 2, Vol. 11, No. 2*, pp. 101–139, pls. 9–11.

YAMANOUCHI, N. & HIRATA, M. (1936): Discovery of the Triassic Formation in Ino Basin, Province Tosa. *The Globe, Vol. 26, No. 3*, pp. 190–194.

YEHARA, S. (1927): Faunal and Stratigraphical Study of the Sakawa Basin, Shikoku, *Japan. J. Geol. Geogr., Vol. 5*, pp. 1–40, pls. 1–6.

ZEIL, W. (1959): Marine Mittel Trias in der Hochkordillere der Provinz Atacama (Chile) (mit einem paläontologischen Beitrag von K. ICHIKAWA). *N. Jb. Geol. Pal., Abh., Bd. 106, H. 3*, S. 339–351.

THE HALOBIIDAE FROM THAILAND

By

T. KOBAYASHI aud A. TOKUYAMA

With Plate IV

In his reconnaissance Wallace LEE discovered fossils on the road side 8 km. south of Chiang Rai near the northern border of Thailand. They were submitted by him to the U.S. Geological Survey in 1923. T. W. STANTON distinguished in the collection, *Hoernesia* (?) spp., *Macrodon* (?) sp., *Myophoria radiata* LOCZY, *Myophoria* sp. ex. gr. *M. leavigata* and *Trigonodus* (?) sp. and suggested Middle Triassic for this fauna.

Later HEIM and HIRTSCHI (1939) found pelecypods in the green shale formation in the north of Lampang on the highway to Chiang Rai. The fossil was identified as typical *Daonella* by WANNER, indicating the Middle to Upper Triassic age for the formation, Still later *Halobia* was identified by IMLAY among the pelecypods from the same locality (BURAVAS, 1957).

Lately, Triassic fossils were found further at two spots of the Mae Moh tributary, 50 km. east of Lampang. According to PITAKPAIVAN (1955) there are three fossiliferous beds. The Mae Moh collections were sent to KUMMEL for identification. As the result the followings were determined and Anisic to Carnic was suggested for the age of the fauna.

1. Doi Chang shale and sandstone containing *Balatonites*, *Beyrichites*, *Paratrachyceras*, *Ptychites* and *Sturia*.
2. Hong Hoi shale and sandstone containing *Paratrachyceras*, *Joanites*, *Halobia*, *Lobites*, *Balatonites* and *Sturia*.

2–3. Doi Chang or Hong Hoi sandstone and shale yielding *Joanites*, *Ptychites* and *Cladiscites*.

3. Fossiliferous limestone of Doi Chang with *Spirigera*.

Last summer (1958) Mr. Saman BURAVAS, chief of the Geological Survey Division, Royal Department of Mines, Bangkok, Thailand has sent the senior another a small lot of Mesozoic fossils for determination. Beside two specimens from Lampang district there is one from a formation at Na Thawi, Songkhala near Thailand-Malayan border, which was formerly thought Triassic but lately of Carboniferous age. Here the specimen in question is determined as a member of the Triassic Halobiidae and most probably a Carnic species of *Daonella*. Precisely speaking, the Halobiidae from the three loclaities are as follows:

1. *Daonella sumatorensis* from Na Thawi (S 1017/1938). This species was first described from northern Sumatra. According to VOLZ it coexists with *Daonella cassiana* and 6 spcies of *Halobia* including *styriaca* and cfr. *charlyana*. He assigned this fossil horizon to the Raibl equivalent.

2. *Daonella* sp. ex gr. *D. pichleri* from about 60 km. on Lampang—Chiang Rai Highway (TF 4). It is not so well preserved to discuss in detail.

3. *Halobia* cfr. *comata* and *H.* cfr. *styriaca* from a locality (TF 167) east of Lampang. *H. comata* is one of the most abundant species in Timor and a lower Carnic index in the eastern part of the Tethyan province, occurring from the Himalaya, Yunnan and South China. *H. styriaca* is another leading member of the Timorian fauna with which this Thailand form

is most probably conspecific. They are, however, not quite identical with *H. styriaca* (s. str.) which is an index to the Carnic stage of the North Alps, Dinaric Alps, Greece and (?) Spiti.

Thus these four forms are all related to the Carnic species of the Alpine-Himalayan province and especially of the Southeastern Asiatic regions. None of them is, however, common or closely related to the Carnic species of Japan or East Siberia.

In the recent compilation of the geology of Thailand BROWN and others (1953) proposed "Khorat series" to include the Kamawkala limestone and all other Mesozoic formations with the thought that the age of the series is Triassic and Jurassic. The Khorat series on the Khorat plateau is, however, as pointed out by the senior author (1958), a continental formation containing Dicotyledonous plants which must be either Palaeogene or younger Cretaceous in age. Therefore the marine Triassic and Jurassic formations in the median and western zones of Thailand must be excluded from the Khorat series. It is a remarkable fact that the Khorat series so defined is horizontal or gently undulated, while the Jurassic and Triassic formations are strongly folded. Therefore the principal phase of crustal movement in this part of Southeastern Asia must be in the Cretaceous or late Jurassic period.

The Hong Hoi greenish grey shale containing the Carnic *Halobiae* are distributed at some places between Lampang and Chiang Rai, presumably on the east side of a tectonic boundary between the western and median tectonic zones of Thailand. In further northeast in High Laos HOFFET has shown that the boundary in question is a thrust of the Burma arc on the North Laos arc. It is further a remarkable fact that a similar Carnic shale occurs in the southern part of Peninsular Thailand which the senior author thinks to belong also to the median zone. Then the Carnic Hong Hoi shale as well as the Middle Triassic Doi Chang shale are two important members in the stratigraphy of Thailand.

None of the above Triassic fossils has as yet been described or illustrated. Though the material which the authors examined is small and imperfecet, the above statement is documented with its palaeontological description. Here the authors record their warmest thanks to Mr. Saman BURAVAS for the supply of the interesting material.

Genus *Daonella* MOJSISOVICS

Group of *D. pichleri*

1. *Daonella* (?) ex gr. *D. pichleri* MOJSISOVICS

Plate IV, figure 8

A fragment of a right valve at hand is provided with stout, straight, simple, regular and round-topped ribs, widest in middle and narrowing backwards though still distinct. The ribs suggest the greater possibility of being a *Daonella* rather than a *Halobia*. If so, it may belong to KITTL's *pichleri* group, although its outline is unknown. Its ribs closely resemble those of *pauli* KITTL from the Ladinic of Bukowina, but the anterior flattened subhinge area is not so wide as *pauli*. If the area is absent, it may be related to *reticulata* or *pichleri*.

Occurrence:—Greenish grey shale in stream cutting near 60 km. on Lampang-Chiang Rai Highways, northwest Thailand (TF 4). According to BURAVAS this is in the same horizon with the Hon Hoi shale containing ammonites and *Halobia*. This specimen has been thought a *Halobia*.

2. *Daonella sumatrensis* Volz

Plete IV, figures 5–7.

1899. *D. sumatrensis* Volz, *Z. Deutsch. Geol. Ges., Bd. 51*, S. 30, Taf. 1, Fig. 2, 3.

Description:—Shell small, subovate, obliquely elongated and longer than high. Hinge straight, long, rounded at anterior end and obtusely angulated at posterior end. Umbo prosogyrous at about anterior 1/5. Ribs simple, fine, present only in postero-ventral part; *Posidonia*-like stage long; concentric wrinkles distinct through surface.

Observation and comparison:—A nearly complete specimen (MM 3559/1, fig. 1) is 7.3 mm. long and 4.1 mm. high; several fragmentary specimens similar in size, all somewhat compressed. The ribbing, outline and dimension assign this form to Carnic *sumatrensis* Volz, although ribs are somewhat finer, weaker and a little more than the typical form. Among Japanese species *hiratai* is the closest, but shorter and has a less prominent umbo.

Occurrence:—Several shells in a small slab of fine greenish grey clayslate from a tributary of Khlong Mak, Na Takwi, Songkhla near Malayan Border (S 1017/1938). Volz's is coexistent with 4 *Halobiae* and lies below the *styrica-cassiana* zone in north Sumatra.

Genus *Halobia* Brown

Group of *H. styriaca*

4. *Halobia* cfr. *styriaca* by Krumbeck, 1924.

Plate IV, figure 10.

1924. *Halobia styriaca*, Krumbeck, *Pal. Timor, 22. Bd.*, S. 132, Taf. 187, Fig. 8; Taf. 188, Fig. 10

A photograph of *Halobia* sent from Buravas closely resembles *styriaca* from Timor. It is characterized by subrounded outline, short hinge, regular and later bifurcating ribs and flattened posterior subhinge area. In comparison with typical *styriaca* it is more rounded and has a shorter hinge and more ribs. Renz's Greek form (1906) has a longer hinge and Volz's Sumatra form (1899) bears a smaller number of ribs. Krumbeck's Timor form is closest, although ribs are more numerous and more regularly bifurcated in it. Together with Timor form, it can be separated from the typical Alpine species at least in subspecific rank.

Occurrence:—Greenish shale at railway cutting between Pong Pui and Phaukho, east of Lampang (TF 167). It is correlated to Hong Hoi shale.

Group of *H. comata*

3. *Halobia* cfr. *comata* Bittner

Plate IV, figure 9.

1899. *Halobia facigera* Bittner, *Pal. Indica, Ser. 15, Vol. 3*, p. 45, pl. 7, fig. 15.
1899. *H. comata* Bittner, *ibid.*, p. 46, pl. 7, fig. 13.
1899. *H.* cfr. *comata* Bittner, *ibid.*, p. 47, pl. 7, fig. 16.
1908. *H. comata*, Diener, *ibid., Vol. 5*, p. 47, pl. 3, figs. 2–4.

1912. *H. fascigera*, KITTL, Halobiidae usw. S. 1571.
1912. *H.* cfr. *comata*, KITTL, *ibid.* S. 156.
1912. *H.* cfr. *comata*, MANSUY, *Mem. Serv. géol. de l'Indochine, Tom 1, No. 1, pt. 2.*. p. 130, pl. 24, fig. 6.

A laterally compressed right valve beside fragments is more or less diagonally elongated; umbo prosogyrous, at anterior 2/5 of hinge. Anterior ear wide, gently inflated and divided into two parts; dorsal part narrow and concave, while ventral is wide, inflated and defined by a distinct furrow. Ribs very fine, simple, narrow and not flexiate and weakened posteriorly. Concentric wrinkles distinct in young.

Due to compression postero-median ribs look finest; anterior ones widest; concentric wrinkles most distinct in antero-median part. A posterior subhinge area is fairly wide and provided with or without faint ribs, but whether it is secondary or not is a question.

Comparison:—This species was originally described from the Carnic of the Himalaya. According to KITTL his *comata* group is nearly equilateral, but Timor collection comprises various forms as KRUMBECK (1924) included oblique *fascigera* in it. Thailand specimens are more or less oblique and higher than others, although they are laterally compressed. The ribbing and ear safely assign them to *comata*. If their posterior area is original, they are related to *H.* cfr. *superbescens* by KRUMBECK from Timor, or MOJSISOVICS' original form from Hallstatt. KRUMBECK's is somewhat different in the shape of anterior ear.

Occurrence:—Same as the preceding (TF 167 by BURAVAS).

References Cited

BITTNER, A. (1899): Trias Brachiopoda and Lamellibranchiata. *Pal. Indica, Ser. 15. Vol. 3, Pt. 2*, pp. 1–76, pls. 1–12.

BROWN, G. F. et al. (1953): Geologic Reconnaissance of the Mineral Deposits of Thailand. *Royal Dept. Mines, Geol. Surv., Thailand, Mem. 1.*

BURAVAS, S. (1957): Stratigraphy of Thailand. *Mimeogr. distributed in the IX. Pacific Sci. Congr. at Bangkok.*

DIENER, C. (1908): Ladinic, Carnic and Noric Fauna of Spiti. *Pal. Indica., Ser. 15, Vol. 3, No. 3*, pp. 1–157, pls. 1–24.

HEIM, A. and HIRTSCHI,H. (1939): A Section of the Mountain Ranges of North-western Siam. *Ecl. Geol. Helv., Vol. 32, No. 1.*

KITTL, E. (1912): Materialien zu einer Monographie der Halobiidae und Monotidae der Trias. *Result. wiss. Erf. Balatonsees, 1. Bd, 4. Teil, Pal. Bd. 2*, S. 1–229, Taf. 1–10.

KOBAYASHI, T. (1958): Geology of Thailand and her Surroundings. *J. Geogr. Tokyo, Vol. 67, No. 4*, pp. 1–18.

——— and A. TOKUYAMA (1959): *Daonella* in Japan. *J. Fac. Sci. Univ. Tokyo, Sec. 2, Vol. 12, Pt. 1*, pp. 1–26, pls. 1–4.

KRUMBECK, L. (1924): Die Brachiopoden, Lamellibranchiaten und Gastropoden der Trias von Timor, II. Teil, *Pal. Timor, Lief. 13, Bd. 22*, S. 143–417, Taf. 179–198.

MANSUY, H. (1912): Etude géologique du Yunnan oriental. Paléontologie. *Mém. Serv. Géol. de l'Indochine, Tom 1, fasc. 2.*

PITAKPAIVAN, K. (1955): Occurrences of Triassic Formation at Mae Moh. *Rept. Investigation, No. 1, Royal Dept. Mines, Bangkok.*

RENZ, C. (1906): Über Halobien und Daonellen aus Griechenland nebst asiatischen Vergleichsstücken. *N. Jb. Min, Jg. 1906, I*, S. 27–40.

VOLZ, W. (1899): Beiträge zur geologischen Kenntnis von Nordsumatra. *Z. Deutsch. Geol. Ges., Bd. 51*, S. 27–36, Taf. 1.

T. Kobayashi and A. Tokuyama

Daonella in Japan

Plate I

Explanation of Plate I

Figs. 1, 2: *Daonella indica* BITTNER ..... p. 14
1: Left internal mould (MM 3495), ×1; 2: right internal mould (MM 3478) showing arcuate ribs, ×1; loc.: Zohoin.

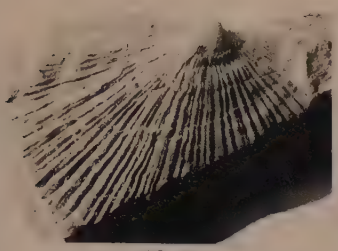
Fig. 3: *Daonella* cfr. *spitiensis* BITTNER ..... p. 15
A right internal mould (MM 3496), ×1.5; loc.: Zohoin.

Figs. 4, 5: *Daonella alta* YABE and SHIMIZU ..... p. 13
4: Gypsum cast of a right external mould (MM 3476), ×1.5
5: a left internal mould with arcuate ribs (MM 3474), ×1; loc.: Zohoin.

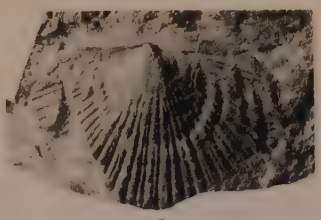
Figs. 6, 7: *Daonella subquadrata* (s. s.) YABE and SHIMIZU ..... p. 19
6: Full grown specimens (MM 3516), ×1
7: a left internal mould (MM 3517), obliqu form, ×1; loc.: Zohoin.

Figs. 8–11: *Daonella subquadrata symmetrica* KOBAYASHI and TOKUYAMA ..... p. 19
8: Holotype (MM 3525), clay cast of a left external mould, ×1.5
9: gypsum cast of a right external mould (MM 3526), ×1.5
10: a right internal mould (MM 3527), ×1
11: a left internal mould (MM 3528), ×1.5; loc.: Zohoin.

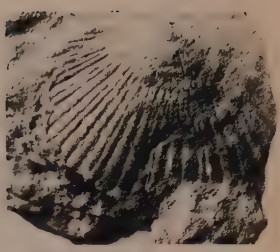
Figs. 12, 13: *Daonella subquadrata zohoinensis* KOBAYASHI and TOKUYAMA ..... p. 19
12: Holotype (MM 3510), a left internal mould, ×1;
13: a right internal mould (MM 3511), ×1; loc.: Zohoin.



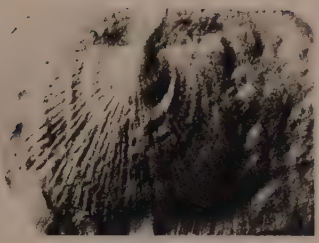
13



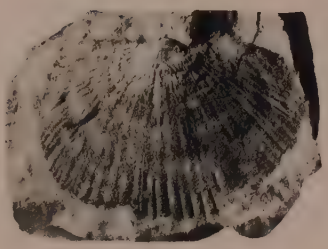
3



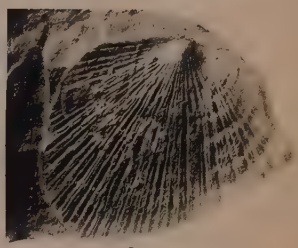
1



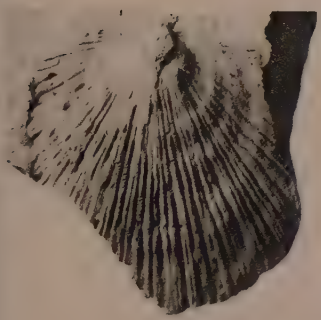
8



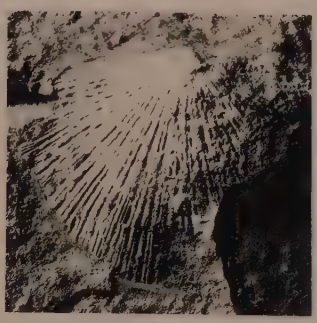
4



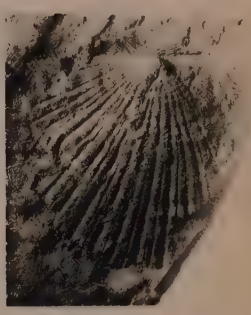
9



11

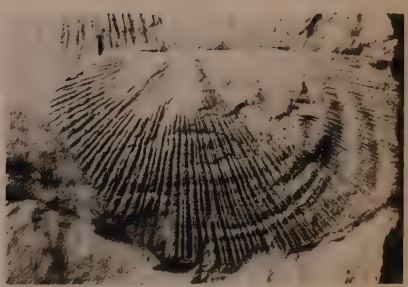


7



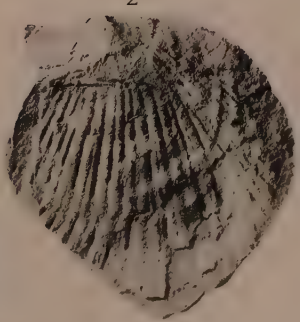
5

6



12

10



2

Plate II

Explanation of Plate II

Figs. 1, 2: *Daonella indica* BITTNER ..... p. 14
Immature left valves; 1: (MM 3486), ×2; 2: (MM 3480), ×3; loc.: Zohoin.

Figs. 3–6: *Daonella kotoi* MOJSISOVICS ..... p. 16
3: Holotype, clay cast of the right external mould (MOISISOVICS' type of Taf. 2, Fig. 3), ×1.
4: a left internal mould (MM 3487) with narrow ribs, ×1.
5: a right internal mould (MM 3488) with wide ribs, ×1.
6: an immature left valve (MM 3489), ×2; loc.: Zohoin.

Fig. 7: *Daonella kotoi* MOJSISOVICS var. ..... p. 17
A variety (MM 3507) with trifurcate ribs, ×1.5; loc. Kuroiwadani near Ino.

Fig. 8: *Daonella sakawna* MOISISOVICS ..... p. 17
Holotype, modeling cast of the MOJSISOVICS' type specimen of Taf. 2, fig. 4 (MM 5002), ×2; loc.: Zohoin.

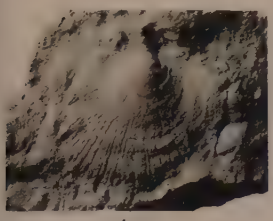
Figs. 9, 10: *Daonella subquadrata* YABE and SHIMIZU ..... p. 19
9: Immature forms of *subquadrata* (s. s.) and *zohoinensis*, MOJSISOVICS' type specimen of *sakawana* (MM 5003), (Taf. 2, Fig. 5), ×2; loc.: Zohoin.
10: an immature right internal mould of *subquadrata* (s. s.) (MM 3518), ×2; loc.: Koretomo near Ino.

Fig. 12: *Daonella pectinoides* KOBAYASHI and TOKUYAMA ..... p. 20
Holotype, (MM 3532), right internal mould, ×2; loc.: Zohoin.

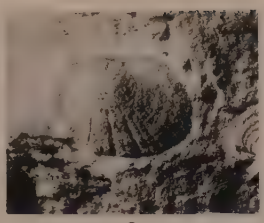
Fig. 13: *Daonella asymmetrica* KOBAYASHI and TOKUYAMA ..... p. 22
Holotype, (MM 3534), left internal mould, ×2; loc.: Zohoin.

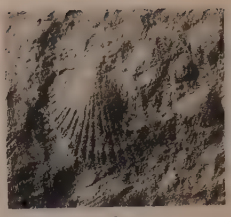
Fig. 14: *Daonella hiratai* KOBAYASHI and TOKUYAMA ..... p. 22
Holotype, (MM 3535), open internal mould, ×2; loc.: Zohoin.

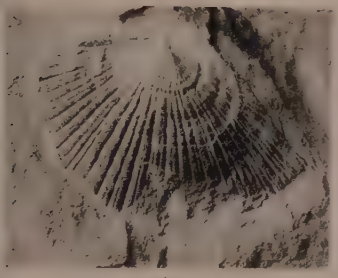
Fig. 15: *Daonella iwayai* KOBAYASHI and TOKUYAMA ..... p. 15
A fragment of an external mould (MM 3498) showing furrows of 3 orders, ×1; loc.: Zohoin.


10

2

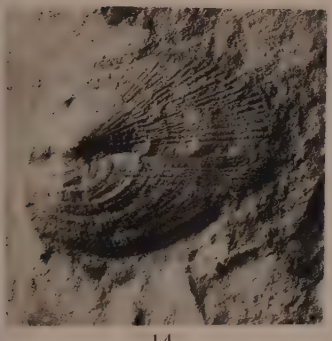

6

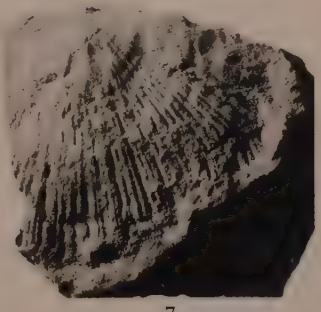

1

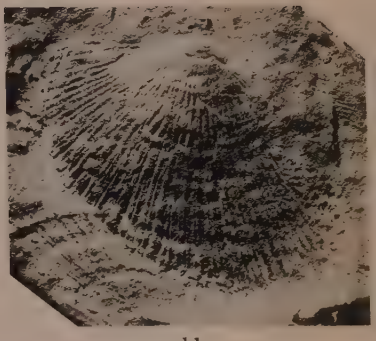

4

12

13

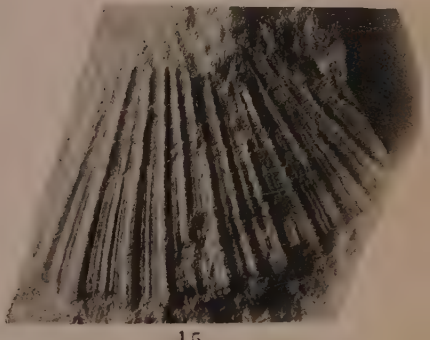

14

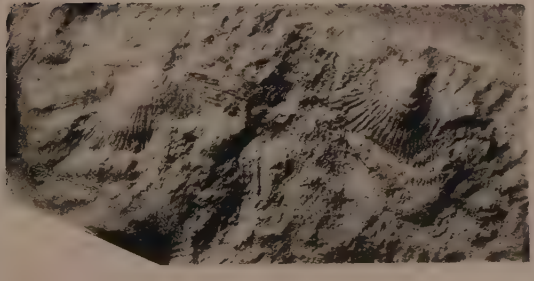

7


11

8

5


15


9

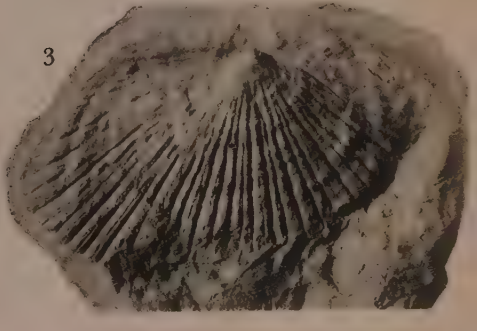

3

Plate III

Explanation of Plate III

Fig. 1: *Daonella kotoi* MOJSISOVICS .....p. 16
A left internal mould (MM 3503), ×1; loc.: Tsuzuradani at Usugatani in the Sakuradani region; HASHIMOTO coll.

Fig. 2: *Daonella yoshimurari* KOBAYASHI .....p. 12
A left valve (MM 3472), ×4; loc.: at a roadside between Shirogawara and Minami Omine.

Figs.3, 4: *Daonella indica* BITTNER .....p. 14
3: A right valve (MM 3538), ×1; loc.: Makio at Usugatani.
4: a deformed left internal mould (MM 3539), ×1; Naise at Junisha in the Sakuradani region; HASHIMOTO coll.

Fig. 5: *Daonella subquadrata zohoinensis* KOBAYASHI and TOKUYAMA .....p. 19
Immature specimens (MM 3514) showing *Posidonia*-like stage, ×3; loc.: Koretomo.

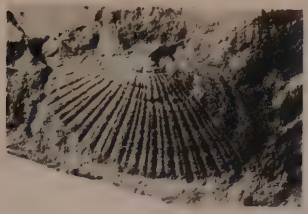
Fig. 6: *Daonella pectinoides* KOBAYASHI and TOKUYAMA .....p. 21
A left valve (MM 3533), ×5; loc. Koya-Mizo; HASHIMOTO coll.

Fig. 7: *Daonella multistriata* YABE and SHIMIZU .....p. 20
Holotype, modelling cast of the YABE & SHIMIZU's type specimen of pl. 11, fig. 12, (MM5004), ×1; loc.: Rifu, Tohoku Univ. coll.

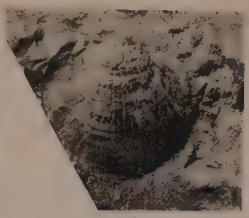
Figs. 8, 9: *Daonella iwayai* KOBAYASHI and TOKUYAMA .....p. 15
8: Holotype (MM 3497), left internal mould, ×1: Tsuzuradani at Usugatani; HASHIMOTO coll.
9: A fragment of a full grown specimen (MM 3481), ×1; loc.: Kuroiwadani.

Fig. 10: *Daonella tenistriata* KOBAYASHI and TOKUYAMA .....p. 13
Holotype (MM 3473), clay cast of an open specimen, ×1.5; loc.: Zohoin.

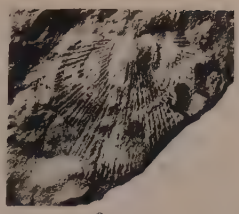
Figs. 11, 12: Sakuradani specimens showing the mode of deformation. .....p. 14
11: *D. indica* (MM 3540), ×1; loc. Tsuzuradani, Usugatani; HASHIMOTO coll.
12: *D. indica* and *subquadrata* (MM 3531), ×2; loc. Junisha.



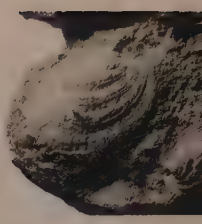
1



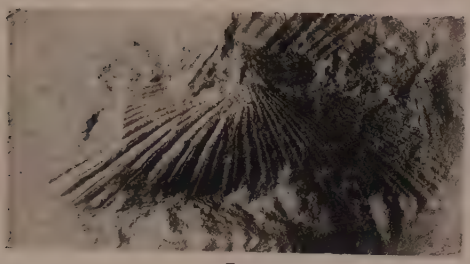
2



3

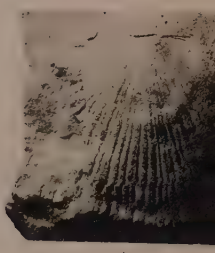


5



7

6



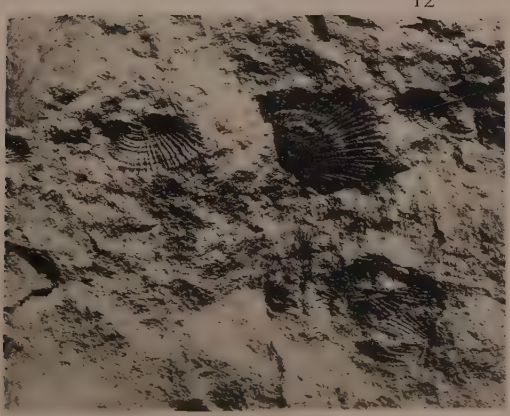
4

8

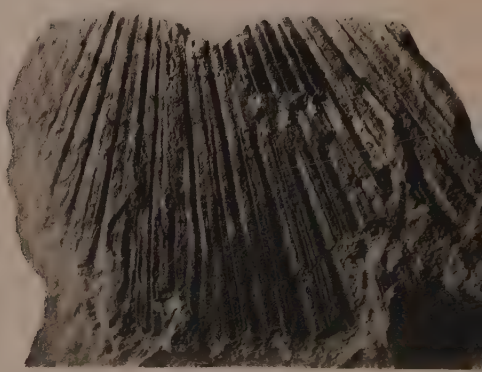
10

11

12



9



T. KOBAYASHI and A. TOKUYAMA

Daonella in Japan
and
The Halobiidae from Thailand

Plate IV

Explanation of Plate IV

Fig. 1: *Daonella indica* BITTNER.....p. 14
A laterally compressed right valve (MM 3485), ×1; loc. Tsuzurazaka at Usugatani in Sakuradani region.

Figs. 2, 3: *Daonella kotoi* MOJSISOVICS.....p. 16
Laterally compressed right valves (MM 3505, 3504), ×2; loc. ditto.

Fig. 4: *Daonella iwayai* KOBAYASHI and TOKUYAMA.....p, 15
A right valve (MM 3537), showing the manner of deformation; ×1, loc. ditto.

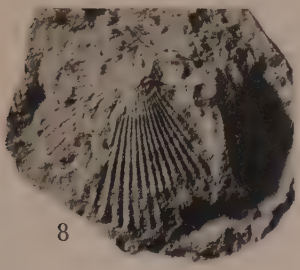
Figs. 5–7: *Daonella sumatrensis* VOLZ.....p. 29
Clay casts of left valves (figs. 1 & 3) and a right valve (MM 3559/1–3), ×3; loc.: Tributary of Khlong Mak, Na Takwi, Songkhla near Malayan Border (S 1017/1938)

Fig. 8: *Daonella* (?) ex gr. *D. pichleri* MOJSISOVICS.....p. 28
A clay cast of a right external mould (MM 3561), ×1.5. Loc.: At a stream cutting near Km. 60 on Lampang-Chiang Rai Highway, northwest Thailand. (TF 4).

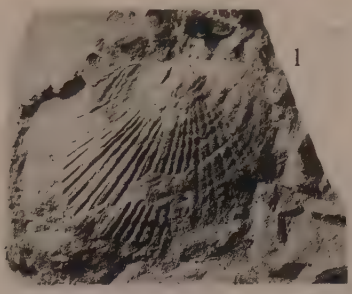
Fig. 9: *Halobia* cfr. *comata* BITTNER.....p. 29
A clay cast of a right external mould (MM 3560); ×1. loc.: At a railway cutting between Pong Pui and Phaukho, east of Lampang (TF 167).

Fig. 10: *Halobia* cfr. *styriaca* by KRUMBECK.....p. 29
A photograph sent from BURAVAS; loc.: ditto.

All illustrated specimens except fig. 10 are kept in the Geological Institute, University of Tokyo.



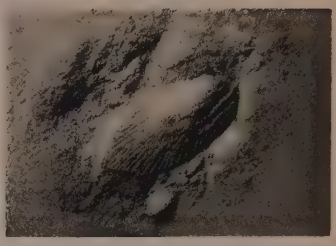
8

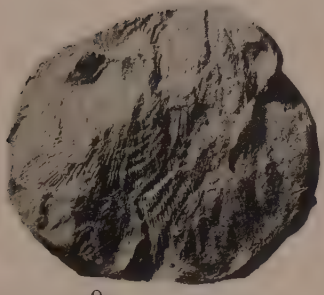


1

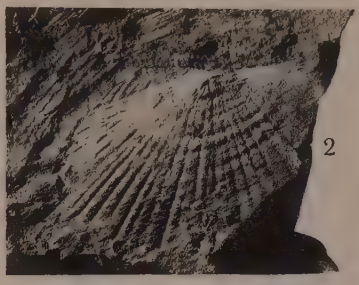
5

6

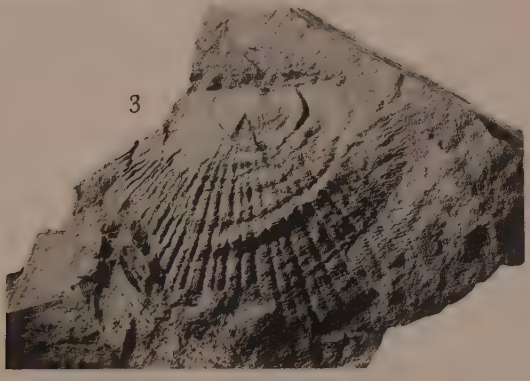




9



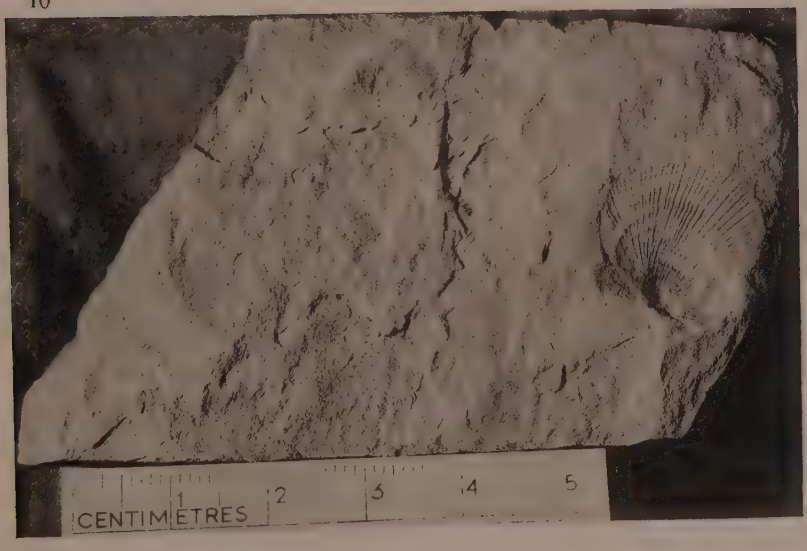
2



3

7

10



4

LOWER LIASSIC LAMELLIBRANCH FAUNA OF THE HIGASHINAGANO FORMATION IN WEST JAPAN*

By

Itaru HAYAMI

With Plates V—VIII.

Abstract

The lower Liassic Higashinagano formation in Yamaguchi Prefecture of West Japan can be stratigraphically divided into five members, namely, basal conglomerate, *Cardinia toriyamai*-, *Prosogyrotrigonia inouyei*-, *Oxytoma*-sandstones and *Coroniceras* (?)-bearing sandy shale. In this paper are described the pelecypods in the sandstones which were only partly reported by YEHARA (1921), TORIYAMA (1938), KOBAYASHI and MORI (1954) and HAYAMI (1957). The predominant genera in this formation are *Parallelodon*, *Grammatodon*, *Oxytoma*, *Chlamys*, "*Aequipecten*," *Entolium*, *Plicatula*, *Plagiostoma*, *Ctenostreon*, *Liostrea*, *Prosogyrotrigonia*, *Cardinia*, *Praeconia*, *Sphaeriola*, *Lucina* (s. l.) and *Protocardia*. *Oxytoma inequivalve*, *O.* cf. *cygnipes*, *Chlamys textoria*, *Entolium* cf. *calvum*, *E.* cf. *lunare*, *Praeconia* cf. *tetragona* and some other forms are identical or comparable with foreign species from the Lias (mainly lower) of Western Europe and some other areas. No species of this fauna is common with the coeval pelecypods of the Niranohama formation in Northeast Japan and the lower Kuruma group in Central Japan. The faunal difference may be partly dependent upon the different sedimentary condition but can be properly attributed to the more or less isolated biogeography.

Contents

Introduction 32
Acknowledgements 34
Biostratigraphy 34
Palaeoecology 36
Significance of the Fauna 37
1. General Remarks 37
2. Comparison with the Pelecypods of the Shizukawa Faunal Province 38
3. Comparison with the Pelecypods of the Kuruma Faunal Province 38
4. Comparison with contemporaneous foreign Pelecypods 39
Systematic Descriptions 40
Family Nuculidae 40
Family Nuculanidae 41
Family Parallelodontidae 42
Family Cucullaeidae 45
Family Mytilidae 46
Family Aviculopectinidae 47
Family Pectinidae 52
Family Amusiidae 57
Family Plicatulidae 60
Family Limidae 62
Family Ostreidae 68
Family Trigoniidae 70
Family Cardiniidae 70
Family Astartidae 71
Family Fimbriidae 74
Family Lucinidae 76

* Received May 25, 1959.

Family Cardiidae 77
Family Pleuromyacidae 77
Incertae Sedis 78
References 79

Introduction

In the western part of Yamaguchi Prefecture (Province of Nagato), West Japan, is seen a splendid sequence of Lower to Middle Jurassic marine sediments, which has been called Toyora group and regarded as one of the most complete Jurassic standards in this country. Since YOKOYAMA (1904a) had described several ammonites from this district, KOBAYASHI (1926) divided it stratigraphically into four formations, namely Higashinagano, Nishinakayama, Utano and Nanami ones in ascending order. Subsequently the last was excluded from the Toyora group (s. s.) by TORIYAMA (1938). Still later MATSUMOTO and ONO (1947) accomplished the zoning of its main part by means of ammonites, whose generic identification was partly emended by ARKELL (1956). Guide fossils are, however, rather scarce in the Higashinagano formation mainly composed of neritic or littoral sandstones, although pelecypods and gastropods are fairly common at some horizons. The palaeontology of the Higashinagano fauna had been commenced by YEHARA (1921) with *Trigonia inouyei*, which was recently referred to *Prosogyrotrigonia* by KOBAYASHI and MORI (1954). TORIYAMA (1938) listed *Leda*, *Pecten* (*Syncyclonema*), *Lima*, *Myoconcha*, *Cardinia* and *Astarte* as the members of the fauna, but they remain undescribed except for a species of *Cardinia* which I (1958e) reported recently. Besides pelecypods, YABE and EGUCHI (1933) described *Anabacia cyclitoides* which was subsequently transferred to *Chomatoseris*. MATSUMOTO and ONO (1947) found *Juraphyllites** (*Harpophylloceras*?) sp. in the lower part and *Arietites* (*Coroniceras*?) sp. in the upper part, and suggested lower Lias for the formation. The opinion was later upheld by SATO (1956) when he found a *Vermiceras*-like ammonite in KOBAYASHI's collection.

Table 1. List of Fossils of the Higashinagano Formation

Species \ Locality	Takayama		Higashinagano				Higashinakayama		
	1	2	3	4	5	6	7	8	9
Pelecypoda									
Nuculopsis (*Palaeonucula*) sp.					R				
Nuculana (*Dacryomya*) *toriyamae*, n. sp.					R			R	
Parallelodon infraliassicus, n. sp.					C				
Parallelodon cf. *infraliassicus*					R				
Parallelodon (?) *subnavicellus*, n. sp.					R				
Grammatodon toyorensis, n. sp.					C				
Modiolus magatama, n. sp.			R					R	
Meleagrinella japonica, n. sp.			R		?			R	R
Oxytoma cf. *cygnipes*					R				

* =*Rhacophyllites* auct., non ZITTEL, 1884.

	1	2	3	4	5	6	7	8	9
Oxytoma kobayashii, n. sp.									R
Oxytoma inequivalve				R					C
Chlamys textoria			R		C				
"*Aequipecten*" *toyorensis*, n. sp.					C	R			
"*Aequipecten*" sp.					R				
Entolium cf. *calvum*			C	?	C			C	
Entolium cf. *lunare*			R						
Entolium sp.									R
Entolium (?) sp.			R		R			C	
Plicatula subcirsularis, n. sp.					C				
Plicatula praenipponica, n. sp.					C				
"*Lima*" sp. indet.									R
Plagiostoma kobayashii, n. sp.					R				
Plagiostoma matsumotoi, n. sp.			R		C	R		R	?
Plagiostoma sp.									R
Antiquilima nagatoensis, n. sp.					R				
Ctenostreon japonicum, n. sp.					R				
Ctenostreon sp.					R				
Liostrea toyorensis, n. sp.	?				C				
Lopha sazanami, n. sp.					R				
Prosogyrotrigonia inouyei		R	C		R	C	R	C	
Cardinia orientalis, n. sp.			R			R			
Cardinia toriyamai					C			R	
Praeconia cf. *tetragona*					C				
Astarte a sp.					R				
Astarte b sp.					R				
Fimbria sp.					R				
Sphaeriola nipponica, n. sp.					C				
Lucina (s. l.) *hasei*, n. sp.					C				
Cardium (s. l.) *naganoense*, n. sp.	C				R				
Protocardia onoi, n. sp.					R				
Pleuromya sp.			R						
Gen. and sp. indet. a					R				
Gen. and sp. indet. b					R				
Gastropoda spp.	C				C	R		R	
Scaphopoda spp.					C				
Ammonite sp.					R				
Brachiopoda sp. (*Rimirhynchia*)					R				
Brachiopoda sp. (terebratuloid)			R						
Hexacorals									
Chomatoseris cyclitoides	C	C	R		C	C	R	C	
Isastraeid gen. and sp. indet.					C				
Crinoid sp. (isocrinid)					R				

Frequency :—C : common, R : rare.

Horizons :—Basal conglomerate (Loc. 1), *Cardinia toriyamai* bed (Loc.5), *Prosogyrotrigonia* bed (Locs. 2, 3, 6, 7, 8), *Oxytoma* bed (Locs. 4, 9).

Lately I collected many pelecypods and gastropods from the Higashinagano formation at many localities, and the collection in this institute was greatly amplified. In this paper are described 43 forms in 28 pelecypod genera including 22 new species as shown in Table 1, and briefly discussed the biostratigraphical, palaeoecological and palaeogeographical significances of this formation.

Fig. 1. Distribution of Lower Jurassic Rocks in Japan

Since most pelecypod specimens are represented by internal and external moulds, it is easy to examine their hinge, other internal characters and surface ornamentation. But simultaneously it is hard to obtain complete external moulds except for several species with comparatively flat valves. Therefore, their complete outlines are properly given by internal moulds. Merit to arenaceous matrix thematerials is almost free from secondary deformation, although their surface-marking are sometimes difficult to examine in detail.

Acknowledgements

The Toyora pelecypods were previously studied by Prof. Teiichi KOBAYASHI of the University of Tokyo, but they remain undersribed except for two inoceramids and a trigoniid. He transferred kindly his manuscript and place the collection of this institute to my disposal. Here I express my most sincere thanks to Prof. Teiichi KOBAYASHI for his kindness and constant encouragement throughout this study. I am also greatly indebted to Dr. Leslie R. COX of the British Museum (Natural History) for his kind and instructive informations replying to my various questions, and to Prof. Tatsuro MATSUMOTO and Prof. Ryuzo TORIYAMA of the Kyushu University and Assist. Prof. Akira HASE of the Hiroshima University for the permission of examining their collections. Assist. Prof. Koichiro ICHIKAWA of the Osaka City University gave me many instructive informations. Thanks are also due to Dr. Katsura OYAMA of the Geological Survey of Japan for his various advices about malacology and zoological nomenclature.

Biostratigraphy

The Higashinagano formation is mainly composed of sandstones of variable grain-size. Generally speaking, the basal part consists of conglomerates or coarse sandstones, and the grain-size becomes gradually finer upwards. Sandstones are sometimes fairly coaly, but usually quartzose, well sorted, massive, light-coloured and non-bituminous. Their matrix is occasionally fairly calcareous. The distribution of this formation is limited to a narrow zone from the west of Takayama

to Yuhara, and it may merge horizontally with bituminous rocks in the southern area of Tabe. (See Fig. 1)

At Takayama the formation begins with a thin basal conglomerate containing *Ostrea* (?) sp., *Modiolus* (?) sp., *Lucina* (s. l.) *hasei* and some gastropods though most of them are too badly preserved to describe palaeontologically (Loc. 1). *Prosogyrotrigonia inouyei* and *Chomatoseris cyclitoides* occur in middle part (Loc. 2).

There are two valleys at Higashinagano where most part of this formation is exposed. At the northern valley the base of unknown, but fine sandstones of middle part yield *Modiolus magatama*, *Chlamys textoria*, *Entolium* cf. *calvum*, *E.* cf. *lunare*, *Plagiostoma matsumotoi*, *Prosogyrotrigonia inouyei*, *Cardinia orientalis*, *Pleuromya* sp. and *Chomatoseris cyclitoides* (Loc. 3). The superjacent hard fine sandstone yields *Oxytoma inequivalve* (Loc. 4). At the southern valley fossiliferous medium sandstones rest clino-unconformably upon the "Toyogatake phyllites" which belong to Sangun metamorphic rocks. There is no basal conglomerate at the valley, and along the basal plane *Plicatula subcircularis* and *Liostrea toyorensis* form a gregarious fossil bank. It is directly overlain by massive grey medium sandstones which bears a striking lenticular fossil bed containing *Chomatoseris cyclitoides*, an isastraeid, columnar stellates of an isocrinid, scaphopods, gastropods, an ammonite and the greater part of pelecypods which are described in this paper (Loc. 5). *Prosogyrotrigonia inouyei* is comparatively rare at this locality. The medium sandstones merge upwards with fine, light grey sandstones which bears occasionally *Cardinia orientalis*, *Chlamys textoria*, "*Aequipecten*" *toyorensis*, *Entolium* cf. *calvum*, *Plagiostoma matsumotoi*, *Prosogyrotrigonia inouyei* and *Chomatoseris cyclitoides* (Loc. 6).

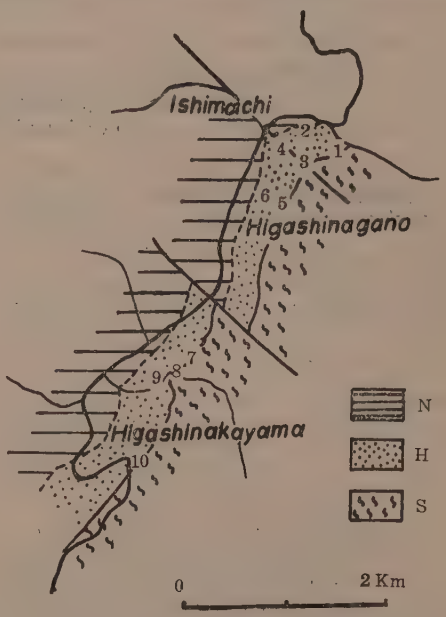


Fig. 2. Index map of Fossil Locality of the Higashinagano Formation in Toyora Asea.
S: Sangun metamorphic rocks;
H: Higashinagano Formation;
N: Nishinakayama Formation.

The Toyogatake phyllites are overlain by a thick basal conglomerate containing numerous colossal boulders of the metamorphic rocks at a valley of Higashinakayama about 2 kilometers southwest of Higashinakano. From an overlying somewhat coaly sandstone several specimens of *Nuculana* (*Dacryomya*) *toriyamae*, *Modiolus magatama*, *Meleagrinella japonica*, *Entolium* cf. *calvum*, *Prosogyrotrigonia inouyei* and *Cardinia toriyamai* were found by Toriyama and myself (Locs. 7 and 8). It is uncertain which fossil bed at Higashinagano this corresponds to, but all species are common with the fauna at Loc. 3, 5 or 6. The overlying hard fine sandstone yields sporadically *Oxytoma inequivalve*, *O. kobayashii*, *Plagiostoma* sp. and "*Lima*" sp. (Loc. 9). Besides, some ill-preserved pelecypods were found at the north of Yuhara, but their specific identification is very difficult. (Loc. 10).

The stratigraphy and division of the Higashinagano formation at these three sections can be summerized as Table 2.

Table 2.

	Takayama	Higashinagano	Higashinakayama
Higashinagano Fm.	Fine sandy shale	Fine sandy shale	Fine sandy shale. *Coroniceras?*
	Not represented	Fine hard sandstone. *Oxytoma inequivalve*	Fine hard sandstone. *Oxytoma inequivalve*, *Oxytoma kobayashii*
	Fine sandstone. *Prosogyrotrigonia inouyei*, etc.	Fine sandstone. *Pr. inouyei*, *Cardinia orientalis*, etc.	Medium sandstone. *Pr. inouyei*, *Cardinia toriyamai*, etc.
	Basal conglomerate. *Lucina hasei*, etc.	Medium sandstone. *Cardinia toriyamai*	Basal conglomerate

Since fossils are restricted to some narrow parts, it is difficult to carry out a biostratigraphical analysis by making a range chart of pelecypod species. The upper part is composed of fine sandy shale, which does not yield pelecypods. But in view of the lithology and predominant pelecypod species, this formation can be divided as follows.

5. *Coroniceras*?-bearing sandy shale ..... 50 m+
4. *Oxytoma*-bearing fine hard sandstone ..... 40–90 m
3. *Prosogyrotrigonia*-bearing fine sandstone..... 30–40 m
2. *Cardinia toriyamai*-bearing medium sandstone..... 20 m
1. Basal conglomerate (sometimes absent) ..... 0–40 m

These five members correspond roughly to Nbc, Nbs, Ncs, Nss and Nsh by MATSUMOTO and ONO (1947) in ascending order. *Chomatoseris cyclitoides* is very common in *Cardinia toriyamai* and *Prosogyrotrigonia inouyei* beds, but unknown in upper horizon. MATSUMOTO and ONO reported *Juraphyllites* (*Harpophylloceras*)? from Nbs (almost equal to *Cardinia toriyamai* bed in my division). The total thickness of this formation measures about 200 meters. If considered that it corresponds lower Lias, the deposition seems fairly rapid, but the value is moderate and not especially large for other Mesozoic basin deposits in Japan.

Palaeoecology

All the pelecypods in this formation are marine. Neither brackish nor fresh water element was found. Two species of the Ostreidae and one of the Mytilidae contained are certainly also marine inhabitants. The mode of fossil occurrence is somewhat different among the fossil beds. In *Cardinia toriyamai* and *Prosogyrotrigonia* beds fossils are crowded and restricted to comparatively small lenses. Valves of pelecypods are never intact and often fragmental with water-worn surface. Apertures of gastropods are often broken. *Chomatoseris cyclitoides* is abundant in the fossil beds, and their reverse situation seen as often as normal one. Therefore it is reasonable to consider that the sedimentation occurred under a certain littoral or neritic condition where sea water was more or less agitated by waves or beach currents.

As supposed from colossal boulders of phyllitic rocks in the basal conglome-

rate, the Sangun metamorphic complex formed a somewhat steep shore line at that time, and the Liassic transgression occurred grandually from the northwestern direction. In *Oxytoma* and *Coroniceras*? beds fossils occur rather sporadically. They are also allochthonous, but the sedimentation may have been carried out under more off-shore and calm condition in view of the fossil-occurrence and lithology. The arenaceous Higashinagano formation passes upwards into argillaceous Nishinakayama formation which yields middle-upper Liassic ammonites, aptychi, belemnites, inoceramids, posidoniids and some pectinids. Because of the absence of upper Sinemurian and lower Pliensbachian ammonite zones, SATO (1957) suggested a certain hiatus between the two formations, but there is no evidence of regression in this period. Anyhow, the Nishinakayama formation shows more offshore and calm deposition than Higashinagano. As noted by MATSUMOTO and ONO (1947), the Nishinakayama ammonite fauna comprises many genera characteristic of the Tethys region. The presence of a colonial hermatypic hexacoral and predominance of tropical pelecypod genera (in Recent seas) such as *Plicatula* and *Fimbria* indicate that the temperature of sea water was fairly warm.

Significance of the Fauna

1. General Remarks

The Higashinagano fauna under consideration comprises more than 40 pelecypod species. Besides, several gastropods, scaphopods, ammonites, brachiopods (including *Rimirhynchia**), a crinoid (columnar stellates of an isocrinid) and hexacorals are found in association. Since no strict time-indicator is found in my collection, I do not intend to say the age of the fauna. But it is noticable that several pelecypods are identical with or closely related to some Liassic (properly lower Liassic) species hitherto known in Europe, northern Africa or Canada. No Triassic (inclusive of Rhaetic) element is found in the fauna. The generic assemblage is quite different from those of the Upper Triassic in Japan and its surroundings. On the contrary, the presence of *Grammatodon*, *Meleagrinella*, *Plagiostoma*, *Antiquilima*, *Ctenostreon*, *Praeconia* etc. suggests that this fauna is not older than Rhaetic. These facts coincide well with the chronology suggested by MATSUMOTO and ONO based on the occurrence of *Juraphyllites* (*Harpophylloceras*?) and *Arietites* (*Coroniceras*?) in this formation.

It is certain that the Higashinagano formation is almost coeval with the lower parts of the Shizukawa and Kuruma groups respectively in northeastern and central Japan. The upper part (*Trigonia*-sandstone) of the Niranohama formation in Shizukawa and Hashiura areas has been considered Hettangian on the basis of *Yebisites* belonging to the Alsatitinae (MATSUMOTO, 1956) and an *Alsatites*-like ammonite (SATO, 1956). The overlying arenaceous shales of the Hosoura formation yield *Arnioceras* and later ammonites (SATO, 1957). As to the Kuruma group, the lowermost dated horizon is upper Pliensbachian indicated by *Amaltheus* and *Canavaria* (SATO, 1955), and there are more than 4,000 meters' thick strata below the horizon (KOBAYASHI et al., 1957). Generally speaking, Liassic pelecypod-bearing rocks in Japan can be classified roughly into three facies, namely bituminous (bakevelliid-eomiodontid) facies, sandstone (trigoniid) facies and sandy shale (ammonite-inoceramid) facies. The Higashinagano

* I thank Mr. A. TOKUYAMA of the University of Tokyo for his identifying of this brachiopod. *Rimirhynchia* has been known chiefly from the Lias of Europe.

formation is not very rich in trigoniids, but the mode of fossil-occurrence, assemblage and lithology bear many alliances to the "*Trigonia*-sandstones" which are commonly seen at several horizons of the Jurassic in Northeast Japan. Bituminous facies is not represented in Toyora area.

The predominant pelecypod genera in this formation are *Parallelodon*, *Grammatodon*, *Oxytoma*, *Chlamys*, "*Aequipecten*," *Entolium*, *Plicatula*, *Plagiostoma*, *Prosogyrotrigonia*, *Cardinia*, *astartids*, *Lucina* (s. l.) and *Sphaeriola*. Characteristic genera of Japan are commonly found in the bituminous facies of the Shizukawa and Kuruma groups, but scarcely in the present fauna. In this respect, the faunas of sandstone facies, in general, bears more cosmopolitan charater than other facies. The tendency agrees well with the fact on the Middle Jurassic Aratozaki fauna (HAYAMI, 1959b) and the Upper Jurassic Soma fauna (TAMURA, 1959, MS).

2. Comparison with the Pelecypods of the Shizukawa Faunal Province.

No common pelecypod species is found between the Higashinagano and Niranohama formations. This fact is probably in part due to different zoogeography between the two areas, if considered that they were distant from each other for more than 1,000 kilometers, as they are. The lower part of the Niranohama formation is composed of bituminous black shales and sandstones. The pelecypod fauna there is composed of *Modiolus*, *Bakevellia*, *Isognomon*, *Geratrigonia*, *Eomiodon*, *Yokoyamaina*, *Thracia* and *Cuspidaria* (YOKOYAMA, 1904b; KOBAYASHI and MORI, 1954; HAYAMI, 1957 a, b, 1958 a, b, c, d; 1959 a). It is readily recognized that the sedimentary environment is different from this formation. But the upper Niranohama formation is a striking "*Trigonia*-sandstone" whose sedimentary condition was seemingly not very apart from this in view of the litho- and fossil-facies. This formation yield no trigoniid but for *Prosogyrotrigonia inouyei*. It is noteworthy that there are no vaugoniids which in turn show acmaeic development coevally in the Niranohama formation.* Its comparable strata at Aikawazawa of Hashiura area bear an undescribed pelecypod fauna whose ecology is very similar to this fauna. In MORI's collection I distinguished *Meleagrinella*, *Chlamys* and *Plagiostoma*, though none is conspecific with those of this formation. It is interesting that the change of bio- and litho-facies from the lower part of this formation to the upper is comparable with that from the upper Niranohama to the lower Hosoura formation. These two sequences in western and northeastern Japan must be almost coeval and show as a whole a transgressive period after the Rhaetic emergence called "Toyogatake phase" by KOBAYASHI (1941). In the mode of fossil-occurrence and assemblage in categories higher than generic, the Higashinagano is especially similar to the Aratozaki formation in Shizukawa area, although the age of the latter is interpreted as Bajocian. The formation yields in some similarly lenticular fossil beds *Oxytoma*, *Entolium*, *Ctenostreon* and some other common genera with the Higashinagano besides some ammonites, brachiopods and colonial hexacorals (HAYAMI, 1959b). The resemblance may be due to the similar sedimentary condition.

3. Comparison with the Pelecypods of the Kuruma Faunal Province**

Between the Higashinagano and Kuruma pelecypod faunas there is only one

* The acme of *Vaugonia* is found in the Dogger and later in Europe, but it appears much earlier (Lias) in Japan (KOBAYASHI and MORI, 1955).

** Inclusive of the Iwamuro and Yamaoku formations whose pelecypod faunas are closely related to that of the Kuruma group.

comparable form, *Entolium* cf. *calvum*. Generally speaking, the Higashinagano formation is quite different from the bituminous rocks of the Kuruma group in lithology and hence they probably differ also in sedimentary condition. As suggested by KOBAYASHI et al. (1957), the Kuruma group was accumulated in an intermontane basin which formed a profound embayment. The presence of *Amaltheus* (SATO, 1955) shows that the Kuruma sea, at least temporarily, connected with the boreal ocean. The Kuruma pelecypod fauna comprising more than 45 species, which I described in papers of another series (1957 a-e, 1958 a, b, d) is composed of very different genera from the present one. The main constituent genera are *Mytilus*, *Bakevellia*, *Isognomon*, *Radulonectites*, *Cardinioides*, *Eomidon*, *Crenotrapezium*, *Thracia* and *Cuspidaria* (?) which are unknown in this formation. No trigoniid sandstone is represented in the Kuruma faunal province, but the lower part of the Domerio-Toarcian Shinatani formation (Ks[1] in KOBAYASHI et al., 1957) and a sandstone at Kamikawara are exceptionally non-bituminous and lithologically comparable with this. Such sandstones yield some pectinids and oxytomids which are never seen in other horizons of the Kuruma group. It may be an evidence that the assemblage of the Liassic pelecypods in Japan are generally much dependent on the sedimentary environment. But considering that the ammonite faunas of the two districts are also composed of different elements from each other, the Toyora area probably belonged to the third faunal province different from the Shizukawa and Kuruma ones.

Unfortunately no Liassic pelecypod fauna is known in the Outer Zone of Southwest Japan. But I expect that such a fauna, if discovered therefrom in future, is of similar generic assemblage to the present one of sandstone facies, since the Upper Jurassic Torinosu and Soma faunas bear many common genera with the Higashinagano and also cosmopolitan characters.

4. Comparison with Contemporaneous Foreign Pelecypods

Most of the Higashinagano pelecypods are new or indeterminable species, but several are identical or comparable with certain foreign Liassic species as listed below.

1) *Nuculana* (*Dacryomya*) *toriyamae* is fairly similar to *Leda texturata* from the lower Lias of France and *Nuculana* (*Dacryomya*) *graphica* from the middle Lias of Crimea.

2) *Parallelodon infraliassicus* is very similar to *Parallelodon buckmani* from the lower Lias of England. *Parallelodon* (?) *subnavicellus* resembles *Cucullaea navicella* from the lower Lias of France.

3) *Oxytoma* cf. *cygnipes* is almost indistinguishable from *O. cygnipes* from the lower to middle Lias of Europe and Canada. *Oxytoma inequivalve* is said to be a cosmopolitan species, though its distinction from certain Dogger and later species must be further studied on circum-Pacific specimens.

4) *Chlamys textoria* is also regarded as a cosmopolitan Liassic species. Its occurrence was hitherto reported from Morocco, Indonesia, Eastern Siberia, Mexico, Chile and Argentina besides Europe.

5) "*Aequipecten*" *toyorensis* is related to *Pecten priscus* from the lower Lias of Europe. "*Aequipecten*" sp. resembles *Pecten* (*Aequipecten*) cf. *semiarticulatus* from the middle Lias of Morocco.

6) *Entolium* cf. *calvum* and *E.* cf. *lunare* are certainly close allies to *E. calvum* and *E. lunare* from the lower Lias of Europe respectively.

7) *Plicatula praenipponica* is fairly similar to *P. daharensis* from the middle Lias of Morocco, though specifically distinguishable.

8) *Plagiostoma kobayashii* may be a close ally to *Lima garlandica* from the lower Lias of Alps, although some other similar forms are known in later horizons.

9) *Antiquilima* is known from the Lias and Aalenian of Europe, though no intimate species to *A. nagatoensis* is found.

10) *Prosogyrotrigonia inouyei* is related to *P. timorensis* from the Rhaetic of Timor, as noted by KOBAYASHI and MORI (1954).

11) *Cardinia* is common in the Upper Triassic in Japan, but in Europe and other region its greater development is seen in the lower Lias. *Cardinia toriyamai* is somewhat similar to several species from the lower Lias of Europe and Siberia, as noted before. *Cardinia orientalis* resembles *C. philea* from the Lias of Europe and its comparable form from Crimea and (?) Indochina.

12) There is a comparable form with *Praeconia tetragona* from the lower to upper (?) Lias of Europe.

Because of the different state of preservation and slight morphological or dimensional differences, it is impossible to answer with certain confidence whether these Toyora forms described under the same specific names are actually identical with foreign species. But they belong evidently to the same species groups. Since the distribution of these European species has not yet been clarified sufficiently in the eastern Tethys and Southeast Asia, it is difficult to determine whether such morphological differences are attributed to "Formenkreis" within one species, geographical subspecies or distinct species. In the circum-Pacific region many Liassic pelecypod faunas were announced from Indochina, Borneo, Timor, Molucca, New Guinea, New Caledonia, New Zealand, Lower Amur, North Alaska, Yukon, British Columbia, Alberta, Nevada, Mexico, Peru, Chile, Neuquen, Mendoza and Patagonia. The records of lower Liassic pelecypods are, however, still limited only to a few areas of them. Since the Upper Jurassic faunas bear many similarities to those of India, Somaliland, East Africa and Syria, the faunas of the Tethys region seem especially important for a study of this kind.

Systematic Descriptions

Family **Nuculidae** GRAY

Genus *Nuculopsis* GIRTY, 1911

Type-species:—*Nuucula girtyi* SCHENCK, 1934, Carboniferous, U. S. A. (=*Nucula ventricosa* HALL, 1858, non HINDS, 1843).

Subgenus *Palaeonucula* QUENSTEDT, 1930

Type-species;—*Nucula hammeri* DEFRANCE, 1825, upper Lias to lower Dogger, Europe (original designation).

Nuculopsis (*Palaeonucula*) sp. indet.

Plate V, Figure 1

Six minute specimens are at hand. Shell small, trigonal, nuculiform, inequilateral with a fairly posteriorly located umbo, much longer than high, strongly inflated (MM 3350, right internal mould, 5.0 mm. long; 4.0 mm. high; 1.5 mm. thick); antero-dorsal margin about 1.5 times as long as postero-dorsal, nearly straight; both margins meeting each other at beak with an obtuse angle of about 105 degrees; hinge composed of an anterior and a posterior series of

taxodont denticles which are interrupted below beak; anterior denticles fairly stout, more than 9 in number; posterior ones much weaker and smaller in number; chondrophore unknown; adductors not strongly impressed; inner ventral margin smooth; surface smooth but for growth-lines.

Although QUENSTEDT's original diagnosis of *Palaeonucula* (as a section) is inapplicable for typical Jurassic species (SCHENCK, 1934; COX, 1940), the subgenus may include most Jurassic nuculids*. Judging from the developed anterior denticles, smooth inner ventral margin and geological occurrence, this can be referred to the subgenus. Because of the coarse-grained matrix, the detail of hinge characters and surface markings are not preserved. *Nucula navis* PIETTE in TEROUEM and PIETTE (1868) from the lower Lias of Paris basin has similar outline and dentition, but the dimensions of these specimens may be much smaller than that species.

Occurrence:— Common in *Cardinia toriyamai* bed at Higashinagano (Loc. 5).

Family **Nuculanidae**

Genus *Nuculana* LINK, 1807

(=*Leda* SCHUMACHER, 1817)

Type-species.—*Arca rostrata* GMELIN, Recent (monotypy).

Subgenus *Dacryomya* AGASSIZ, 1840

Type-species.—*Nucula lacryma* SOWERBY, 1824, Dogger, Europe (by HERRMANNSEN, 1846)

Nuculana (*Dacryomya*) *toriyamae* HAYAMI, new species

Plate V, Figures 2, 3

1938, *Leda* sp. listed by TORIYAMA, *Jour. Geol. Soc. Japan*, *Vol. 45*, *No. 533*, p. 251.

Description:— Shell medium for genus, very inequilateral, equivalve, elongated and rostrated posteriorly, not strongly inflated, about twice or more as long as high, becoming gradually narrower toward posterior and sharply pointed at the extremity; anterior margin short, rounded, postero-dorsal long, broadly concave; ventral broadly arcuate; umbo not very prominent, not strongly recurved, obviously opisthogyrous, lying at about a third or a little more of shell-length from front; numerous taxodont denticles arranged along pre- and post-umbonal margins; surface smooth except for faint concentric lines of growth; anterior adductor scar orbicular, clearly marked; pallial sinus unknown; escutcheon not impressed.

Measurement in mm.	Length	Height	Thickness
Holotype (MM 3352) left in. mould	14.0	7.0	2.0+
Paratype (MM 3353) left ex. mould	16.0	7.0	2.0+

* COX (1940) and many authors regarded *Palaeonucula* as a subgenus of *Nucula* LAMARCK, 1799, and FRENEIX (1958) as a subgenus of *Nuculoma* COSSMANN, 1907.

Observation and comparison:— Represented by six specimens showing internal and external characters. According to COX (1940, p. 29), *Ryderia*, a group of Liassic nuculanids, is separable from *Dacryomya* by the more elongated rostrum, less prominent and scarcely incurved umbo and not impressed escutcheon. In the rostrate outline and other external features this species resembles *Ryderia* better than *Dacryomya*. But the name of *Ryderia* is said to have been proposed by WILTON (1830) for a figured but specifically unnamed shell. As the validity of the name as a subgenus cannot be warranted here, I refer it to *Dacryomya* provisionally.

Nuculana (*Dacryomya*) *doris* (d'ORBIGNY, 1850) (COX, 1936) (=*Nucula complanata* GOLDFUSS, 1836) from the Lias of Europe is specifically different from this in the more pointed and probably more flattened posterior rostrum. This is probably a close ally to *Nuculana* (*Dacryomya*) *graphica* (TATE, 1870) from the Lias of England and the Pliensbachian of Crimea (PČELINCEV, 1937), but the posterior rostrum may be more elongated in this species. This is also similar to *Leda tenuistriata* PIETTE and *Leda texturata* TERQUEM and PIETTE, 1868, from the lower Lias of Paris basin. The surface ornaments of this species are indiscernible probably because of the coarse matrix, but the concentric lamellae, even if present, are not so prominent as the French species. Moreover, the posterior rostrum seems more strongly curved upwards in this species. Besides, "*Nucula*" figured by QUENSTEDT (1858, p. 55, pl. 5, fig. 14–1) from the Lias α may be related, but the posterior rostrum is neither so curved nor so pointed at the extremity as the present species. *Nuculana* (*Dacryomya*) *stendolichos* KIMURA, 1956, from the Upper Jurassic Torinosu group shows an outline of typical *Dacryomya*, and easily distinguishable from this in the more inflated and more elliptical shell-body and more strongly recurved umbo.

Occurrence:— Rare in *Cardinia toriyamai* bed at Higashinagano (Loc. 5). The holotype procured by TORIYAMA at Higashinakayama (Loc. 8).

Family **Parallelodontidae** DALL

Genus *Parallelodon* MEEK and WORTHEN, 1866

[(=*Macrodon* BUCKMAN, 1844 non MÜLLER, 1842; *Beushausenia* COSSMANN, 1897)

Type-species:—*Macrodon rugosus* BUCKMAN, 1844, Dogger, England (original designation).

Parallelodon infraliassicus HAYAMI, new species

Plate V, Figures 4–6

Description:— Shell medium to small, quadrate, inequilateral with a slightly expanded posterior part than anterior, about twice as long as high, strongly inflated; anterior margin gently arcuate, forming about 100 degrees with hinge-line; posterior one sometimes fairly sinuated, meeting hinge-line with an obtuse angle; ventral margin subparallel to hinge or slightly prosocline, provided with a sinuation of variable depth in middle part which corresponds with median sulcus on surface; hinge-line long, linear, occupying nearly shell-length; umbo slightly rising above hinge-line, not recurved, lying at about two-fifths of hinge-line from front; dentition *Grammatodon*-like, asymmetrical, composed of two or three elongated subhorizontal posterior teeth, about six prosocline anterior ones and several small opisthocline median ones; anterior and median

ones subsymmetrically divergent from a point at base of hinge-plate just below beak; cardinal (ligament) area very narrow; adductors weakly impressed, pallial line distinct, slightly sinuated near ventral sinus; surface marked with several irregularly spaced concentric growth-lamellae and numerous fine radial threads.

Measurement in mm.	Length	Height	Thickness
Holotype (MM 3355) left in. mould	18.5	9.0	4.0
Paratype (MM 3356) left in. mould	22.5	11.5	5.5
Paratype (MM 3357) left ex. mould	12.0	6.0	3.0

Observation and comparison:— Represented by seven specimens which reveal clearly the surface-markings and dentition. In the non-alate outline this is somewhat different from typical *Parallelodon* composed of *P. rugosus* and *P. hirsonensis*, and can be included in *Beushausenia* of ARKELL's sense. The hinge of this species seems also more or less deviated from that of *rugosus* (ARKELL, 1930, p. 299, fig. 1; pl. 14, figs. 1, 2), for the anterior teeth are opisthocline and denticles not divergent from a point below the umbo in ARKELL's. Such a dentition as this species is commonly seen in *P. buckmani* RICHARDSON, *P. keyserlingii* (D'ORBIGNY) and many other Jurassic parallelodontids which were grouped by ARKELL (1930) as subgenus *Beushausenia* COSSMANN,, 1897. ARKELL regarded the absence of posterior wing as a subgeneric criterion to distinguish it from *Parallelodon* (s. s.). Subsequettly BRANSON (1942) pointed out that the type of *Beushausenia*, *Macrodon hirsonensis* D'ARCHIAC, 1842, is assignable to *Parallelodon* (s. s.), and proposed *Cosmetodon* for *Arca keyserlingii* D'ORBIGNY by ARKELL (1930, pl. 14, fig. 9, 9a) as the substitute of *Beushausenia* in ARKELL's sense. *Cosmetodon*, however, cannot be anyhow accepted as a substitute of *Beushausenia* COSSMANN, because of the different type species. Prior to BRANSON, COX (1940) stated that the development of wing is fairly variable within one species of the living Arcidae. As to hingement, COX* is of opinion that no generic distinction between *P. rugosus* and *P. keyserlingii* cannot be based on the hinge-teeth and other characters which are very similar in both species. In fact, the inclination of anterior and median denticles is somewhat variable within one species as I (1959 a) noted about *P. niranohamensis* HAYAMI, 1958c.

In the dentition, narrow cardinal area and quadrate outline this is very close to *Parallelodon buckmani* (RICHARDSON) in ARKELL (1930, pl. 14, fig. 8) from the lower Lias of England. But the shell is smaller and slightly more elongated, the umbo being more posteriorly located and the posterior teeth much shorter. The ventral sinuation in *buckmani* is probably not so distinct as this species. *Parallelodon niranohamensis* HAYAMI, 1958c, from the Hettangian of North Japan is an almost coeval species and similar in the surface-markings. That species has, however, a much broader hinge-plate, more terminal umbo and more clearly impressed anterior adductor scar. This is somewhat similar to *Beushausenia* (*Areocucullaea*) *daharensis* DUBAR, 1948, from the Domerian of Morocco, but the cardinal area is much narrower than DUBAR's In one left external mould the median sulcus is considerably deep as if it belong to *Torinosucatella* TAMURA,

* According to his personal communication.

** *Catella* was originally established as a subgenus of *Grammatodon*, but NICOL (1954) said "It is probably a parallelodontid."

1959b. *Torinosucatella* was proposed as a subgenus of *Catella* HEALEY, 1908,** but seems more related to *Parallelodon* than *Catella* or *Grammatodon*, judging from the presence of fine radial threads on the surface, elongated outline and the absence of posterior carination.

Occurrence:—Common in *Cardinia toriyamai* bed at Higashinagano (Loc. 5).

Parallelodon cf. *infraliassicus* HAYAMI

Plate V, Figures 7a, b

Represented by a well preserved right specimen composed of external and internal moulds. Shell medium, about 2.5 times as long as high (MM 3359, 24.5 mm. long; 10.0 mm. high; 4.0 mm. thick), well inflated, a little alate posteriorly; posterior margin slightly sinuated below posterior wing; ventral sinuation broad but indistinct; umbo located at about a third from front; hinge same as typical *infraliassicus*.

This is different from the typical form from the same fossil bed in the more elongated outline, posteriorly expanded shell and more anteriorly located umbo. The posterior wing is absent in the typical form but distinct in this. But if consider that the variability of outline is often great in one parallelodontid species, it is probable that this is merely a varietal form of the preceding species.

Occurrence:—Rare in *Cardinia toriyamai* bed and Higashinagano (Loc. 3)

Parallelodon (?) *subnavicellus* HAYAMI, new species

Plate V, Figures 18, 19; Plate III, Figure 17

Description:—Shell medium, inequilateral, elongated-ovate, modarately inflatted, about 2.5 times as long as high (holotype, MM 3360, right internal mould, 41.0 mm. long; 17.0 mm high; 6.5 mm thick); anterior margin broadly arcuate, rounded at the dorsal extremity; ventral one nearly straight, subparallel to hinge without ventral sinuation; posterior margin very oblique, not sinuated, passing gradually into dorsal margin without any angulation; umbo recurved, but not highly rising above hinge, lying at about a third of shell-length from front; surface marked with fine concentric lamellae and numerous faint growth-lines; radial marking absent at all; hinge consisting of two rather weak subhorizontal posterior and number of granular anterior and median teeth on a narrow hinge plate; no plate for adherence of posterior adductor; musculature and ligament structure unknown.

Observation and comparison:—Represented by a specimen which is composed of right internal and external moulds. The outline and the absense of ventral sinus and radial ornamentation are very strange for *Parallelodon*. The hinge structure is, however, related to the genus. In fact, the obtuse postero-dorsal truncation reminds one of a cucullaeid, but the outline is too elongated and the hinge too asymmetrical to refer it to that genus. This is somewhat similar to *Cucullaea wellmanni* MARWICK, 1953, from the Oretian-Otamitan (mainly Carnic) of New Zealand, judging from the outline, dentition and absence of ventral sinus and posterior wing. But this is distinguishable from that species by the rounded antero-dorsal extremity and subparallel ventral margin to hinge-line. *Macrodon* cf. *curionii* Bittner in TRECHMANN (1918), which is identical

with *C. wellmani* according to MARWICK, has more *Parallelodon*-like outline and faint radial ornamentation. *Cucullaea navicella* TERQUEM and PIETTE, 1868, from the lower Lias of eastern Paris basin is very similar to this in the non-alate outline and the absence of radial ornamentation, and evidently congeneric with this. But the outline of the French species is not so elongated as this. Besides, *Parallelodon banburyensis* (SEELEY, MS) from the lower Lias of England may be related to this, judging from the description of external and internal characters by ARKELL (1930, p. 340). But it is said that faint radials are descernible near the ventral margin in that form. This seems to belong to an unnamed genus of the Parallelodontidae.

Occurrence:—Rare in *Cardinia toriyamai* bed at Higashinagano (Loc. 5)

Family **Cucullaeidae** FINLAY and MARWICK, em. NICOL

Genus *Grammatodon* MEEK, 1860

Type-species:—*Cucullaea inornata* MEEK and HAYDEN, 1858, Lias, U. S. A. (monotypy).

Grammatodon toyorensis HAYAMI, new species

Plate V, Figures 9–12

Description:—Shell small, equivalve, inequilateral, roundly trapezoidal, strongly inflated, sharply carinated postero-ventrally, much longer than high; anterior margin broadly arcuate, subrectangular to hinge-line, passing gradually into venter; ventral margin not sinuated; posterior margin slightly concave, forming a small postero-dorsal wing, fairly abruptly turned into venter at a sharp carination which is gradually weakened towards ventral periphery; hinge-line straight, occupying almost whole shell-length; umbo rising highly above hinge, recurved, lying at about two-fifths of length from front; cardinal area moderate in breadth, provided with several chevron-like ligament grooves; dentition of typical *Grammatodon*, composed of a posterior series of three elongated subparallel teeth and anterior and median series of divergent granular teeth from a point below beak; the anteriormost tooth subhorizontal; no plate for adherence of posterior adductor; surface marked with several radial riblets and fine concentric lines of growth; radials very weak and densely spaced except for about five prominent ones distributed on each lateral area; surface somewhat lanceolate in postero-ventral area but concentric element much weaker in remaining part.

Measurement in mm.	Length	Height	Thickness
Holotype (MM 3361) left in. mould	14.0	9.0	4.5
Paratype (MM 3362) left in. mould	12.0	8.5	4.0
Paratype (MM 3363) left ex. mould	15.0+	8.0+	5.0

Observation and comparison:—Represented by 11 specimens. Although the postero-dorsal part is somewhat unusually auriculated, the small dimensions, dentition, sharp posterior carination, limited distribution of prominent radials in each lateral area and other characters coincide well with those of *Grammatodon* (s. s.) defined by COX (1940). The ornamentation of right valve is unknown in detail, but this is not a member of subgenus *Indogrammatodon* COX, 1937, which is characterized by the different mode of ornamentation on two valves and relatively large dimensions.

In the ornamentation this is fairly similar to *Grammatodon concinnus* (PHILLIPS) and *G. alsaticus* (ROEDER) in ARKELL from the Oxfordian of England and also to *G. andohouensis* COX, 1940, from the Bathonian of Cutch. But the posterior margin is more sinuated to form a more distinct postero-dorsal wing in these specimens, and the dimensions are much smaller. *Grammatodon takiensis* KIMURA, 1956 (TAMURA, 1959 b) from the Upper Jurassic Torinosu group in Southwest Japan is also similar in the surface-markings, but differs from this in the less inflated shell and more trapezoidal outline. *Grammatodon* (*Indogrammatodon ?*) *nakanoi* HAYAMI, 1958 c, from the Hettangian of Northeast Japan is readily distinguishable from this by the presence of widely spaced and stout radials on the whole surface of left valve, less prominent postero-ventral carination, non-alate outline and larger dimensions. *Grammatodon* (?) sp. in HAYAMI (1958 d) from the Domerio-Toarcian of Central Japan differs in having lattice ornaments on the whole shell-surface and more elongated outline, although they are similar in dentition.

In the Triassic there are several species hitherto referred to *Grammatodon*, but I think that they are not typical except for *Macrodon otagoensis* WILCKENS, 1927. This species is probably one of the oldest representative of *Grammatodon* (s. s.). *Grammatodon inaequivalvis* (GOLDFUSS, 1836) (ARKELL, 1930) is almost coeval with this, but it may be a primitive form of *Indogrammatodon*.

Occurrence:—Common in *Cardinia toriyamai* bed at Higashinagano (Loc. 5).

Family **Mytilidae** FLEMING

Genus *Modiolus* LAMARCK, 1799

(=*Volsella* SCOPOLI, 1777; *Modiola* LAMARCK, 1801)

Type-species:—*Mytilus modiolus* LINNÉ, 1758, Recent.

Modiolus magatama HAYAMI, new species

Plate V, Figure 13

Description:—Shell small, modioliform, expanded postero-ventrally, well inflated; shell-obliquity approximately 40 degrees; hinge-line comparatively short, passing gradually into posterior margin with a rounded obtuse angle of about 135 degrees; umbo not terminal; anterior margin rounded, projected to some extent beyond umbo; antero-ventral margin slightly sinuated near junction of anterior wing and main body; anterior wing roundly subtrigonal, occupying about a fifth of whole surface, defined from main body by an inconsipicuous sulcus; greatest convexity lying near center of valve; surface marked with fine concentric lines which are more or less regular in interval; hinge and dysodont teeth not observed, probably undeveloped; ligament structure unknown.

Measurement in mm.	Length	Height	Thickness
Holotype (MM 3366) left in. mould	17.5	13.5	4.0
Paratype (MM 3367) left ex. mould	11.5	7.5+	2.5

Observation and comparison:—Three specimens are at hand. The holotype is the largest and reveals the complete outline. The paratype, though more or less broken, shows fine concentric surface-makings. This species is thus characte-

rized by the small size, short hinge-line, and regular concentric markings. It is somewhat similar to *Modiolus minimus* (SOWERBY, 1821) (DUMORTIER, 1867; PFLÜCKER, 1868; ARKELL, 1933) from the Rhaetic of England. Compared with ARKELL's from the pre-*planorbis* bed of Dorset, it it different in having less trigonal, more curved and elongated outline and less terminal umbo. PFLÜCKER's specimen has probably more irregularly spaced concentric lamellae. The shell convexity seems slightly stronger than the Rhaetic species. In the surface-markings it is allied to *Mytilus tenuissimus* TERQUEM and PIETTE, 1868, from the Lower Lias Paris basin, but the outline is more slender and the anterior wing better defined than that species.

Occurence:—Rare in *Prosogyrotrigonia inouyei* bed at Higashinagono (Loc. 3) and Higashinakayama (Loc. 8).

Family **Aviculopectinidae** ETHERIDGE

Genus *Meleagrinella* WHITFIELD, 1885

(=*Echinotis* MARWICK, 1935)

Type-species:—*Avicula curta* HALL, Jurassic, U. S. A. (by COX, 1941).

Meleagrinella japonica HAYAMI, new species

Plate V, Figurs 20–22

Description:—Shell small, inequivalve, inequilateral, slightly prosocline, slightly longer than high; left valve strongly inflated, main body suborbicular; anterior wing very small, scarcely defined from antero-dorsal part of main body; posterior wing narrow but distinctly separated, protruded backwards, pointed at extremity; hinge-line short, straight; umbo small, suborthogyrous, situated near mid-length, rising slightly above hinge-line; surface ornamented with more than 45 fine radial riblets, which increase their number by irregular insertion; concentric growth-lamellae fairly prominent; hinge-plate narrow; ligament structure unknown; right valve weakly convex, probably smaller than left, orbicular, provided with a narrow anterior wing and profound byssal notch below it; umbo scarcely rising above hinge; surface apparently smooth.

Measurement in mm.	Length	Height	Thickness
Holotype (MM 3368) left in. mould	15.0	13.5	4.5
Paratype (MM 3369) left in. mould	10.0	9.5	3.0
Paratype (MM 3370) right in. mould	7.5	8.0	1.5

Observation and comparison:—Represented by internal and external moulds of three left valves and a right internal mould. Though the ligament structure is unknown, this is referable to *Meleagrinella* by the orbicular main body, undeveloped anterior wing and surface ornamentation. ICHIKAWA (1958) studied the shell-structure and ligament of *Meleagrinella* and included the genus in his new subfamily Oxytominae. Although no attempt has been made to reexamine the taxonomic position of many Jurassic species hitherto referred to *Pseudomonotis*, most of them are considered to belong to *Meleagrinella*. In the outline and development of the posterior wing resembles *Meleagrinella echinata* (SMITH) (SOWERBY, 1819; MORRIS and LYCETT, 1853; POMPECKJ, 1901; ROLLIER, 1914; DOUGLAS and ARKELL, 1932; MARWICK, 1935; COX, 1940, etc.), a famous, world-

widely distributed Middle Jurassic species. According to Cox (1940) the radial ribbing of *echinata* is fairly variable among Cutch specimens, but the present specimens have more delicate and densely speed radials than any of that species. This differs from *Pseudomonotis ovalis* (PHILLIPS) in ARKELL (1933) and *P.maltonensis* ARKELL, 1933, from the Corallian in the less oblique and more developed and and pointed posterior wing. *Avicula substriatus* ZIETEN (GOLDFUSS, 1836; CHAPUIS and DEWALQUE, 1853) from the Lias of Europe has also an obtuse posterior wing and more prosocline main body. *Monotis olifex* and *M. papyria* QUENSTEDT, 1856, from the lower Lias have more expanded areas and obtuse postero-dorsal extremities, though the mode of radials seems fairly similar.

Occurrence:—Rare in *Prosogyrotrigonia inouyei* bed at Higashinagano (Loc. 3) and Higashinakayama (Loc. 8). A similar form occurs in Y_2 beds of the Yamaoku formation at Osakabe, northern Okayama Pref. (listed as *Pseudomonotis* n. sp. by KONISHI, 1954).

Genus *Oxytoma* MEEK, 1864

Type-species:—*Avicula münsteri* (BRONN nom. nud.) GOLDFUSS, 1836, Middle and Upper Jurassic, cosmopolitan (original designation)

Oxytoma cf. *cygnipes* (YOUNG and BIRD)

Plate V, Figure 14

cf. 1822, *Pecten cygnipes* YOUNG and BIRD, Yorkshire, pl. 9, fig. 3.
cf. 1839, *Avicula cygnipes* PHILLIPS, Illust. Geol. Yorkshire, I, pl. 14, fig. 3.
cf. 1839, *Avicula longicostata* STUTCHBURY, *Ann. Mag. Nat. Hist., N. S., Vol 2*, p. 163 (non Strickland).
cf. 1857, *Avicula cycnipes* DUMORTIER, Note sur quelques Fossiles, p. 7, pl. 4, figs. 1–4.
cf. 1869, *Avicula cycnipes* DUMORTIER, Études pal. Dépots jura. Bassin du Rhône III, p. 294, pl. 35, figs. 6–9.
cf. 1957, *Oxytoma cygnipes* FREBOLD, *Geol. Surv. Canada, Mem. 287*, p. 67, pl. 16, figs. 1–5.

Description of Toyora specimen (left valve):—Shell medium for genus, inequilateral, not strongly inflated, thin, probably more or less longer than high (MM 3371, left in. mould, 30.0+mm. long; 26.0+mm. high; 5.5 mm. thick); hinge-line long, straight; anterior wing comparatively small, obtusely truncated; posterior one wide, trigonal, protruded backwards, pointed at extremity; posterior margin broadly sinuated below posterior wing; umbo slightly rising above hinge, lying at about a forth of hinge-length from front; surface ornamented with seven narrow but highly raised primary radial ribs which insert some 30 faint tertiary riblets; secondary ribs distinguishable from tertiaries in posterior half but much weaker than primaries; radials curved forwards in anterior area but almost straight in median and posterior areas; posterior wing smooth except for numerous tertiaries; primaries weakly plicated and impressed on internal surface; growth-lamellae comparatively weak; hinge structure and right valve unknown.

Observation and comparison:—Represented only by a specimen composed of left external and internal moulds. Its ventral peripheral part is broken off. This form obviously belongs to a certain infra-generic group altogether with some Rhaetic and Liassic species such as *Oxytoma cygnipes* (YOUNG and BIRD), *O. scanicum* (LUNDGREN), *O.* sp. in TRECHMANN (1923) and *O. longicostatum* (STRICKLAND). This group is characterized by the comparatively large size, small number of primary ribs which are clearly defined from secondaries and tertiaries in promi-

nence and often give rise to digitations of the ventral margin. Compared with *O. scanicum* (LUNDGREN) (TROEDSSON, 1951) from the Lias of Scania, the shell-convexity seems smaller and the interval of primary ribs not so sulcated. TROEDSSON (1951) noted that the growth-lines between the ribs are concave in *scanicum* but nearly straight in *cygnipes* and *longicostatum*. DUMORTIER's figure (1869) bears more alliances to *scanicum* than *cygnipes* in this respect. *O. longicostatum* (STRICKLAND) (ARKELL, 1933) from the Rhaetic of England resembles this, but the tertiary ribs are probably weaker ahd sometimes small spines appear on the primaries in that species. This is most closely allied to *O. cygnipes* in FREBOLD (1957) from the Sinemurian of the Fernie group in Western Canada. The number of primaries is 5 or 6 in the Fernie form and 7 in the present specimen. The difference, however, cannot serve a specific distinction, since the number of costae is generally variable to some extent within one species of *Oxytoma*.

Occurrence:—Rare in *Cardinia toriyamai* bed at Higashinagano (Loc. 5). *O. cygnipes* was hitherto reported from the Pliensbachian of Europe and the Sinemurian of Western Canada. The present specimen occurs from the basal part of the Higashinagano formation ane its age is assigned to be Hettangian.

Oxytoma kobayashii HAYAMI, new species

Plate V, Figures 15–17

Description:—Shell small, very inequiualve, inequilateral, prosocline, much longer than high; left valve pteriform, strongly inflated; anterior wing well-defined, very small, trigonal, subvertically truncated; anterior margin in its front probably gaped, passing gradually into venter; posterior wing developed, well-defined, flattened, projected backwards beyond posterior extremity of main body, acutely pointed at end; posterior margin deeply sinuated below it; hinge-line straight, unusually long, extending over almost whole shell-length; umbo located at about a sixth of hinge-length from front, recurved, prosogyrous, rising slightly above hinge-line; apical angle exclusive of wings about 80 degrees; surface ornamented with about 11 straight radial costae which are more densely spaced on both lateral areas than on middle part; posterior wing smooth; radials weakly impressed on internal surface; secondary ribs not observed; right valve weakly inflated, having a small, well-defined anterior wing of *Oxytoma*-type and pointed posterior one; byssal notch narrow but deep; surface smooth for numerous fine radial riblets; hinge and ligament structure unknown.

Measurement in mm.	Length	Height	Thickness
Holotype (MM 3372) left in. mould	16.5	12.0	4.5+
Paratype (MM 3373) left valve	9.5	8.0	2.5
Paratype (MM 3374) right ex. mould	12.5	8.5	2.0

Observation and comparison:—Four specimens are at hand. The subterminal umbo, small apical angle and elongated posterior wing are somewhat unusual for *Oxytoma*, and the outline and simple costation of left valve remind one of *Pteroperna* MORRIS and LYCETT, 1853. In the strong inequivalveness and the byssal structure, however, this is referable to *Oxytoma*. The radials of *Oxytoma* are usually composed of more one two orders of promominence in left valve, but secondaries are indiscernible on the surface of the paratype (pl. I, fig. 16). This

is distinguishable from hitherto described species of *Oxytoma* by the small anterior wing, elongated and pointed posterior wing, subterminal umbo, long hinge-line and small apical angle.

Occurrence:—The holotype belongs to an old collection of the Geological Institute, University of Tokyo, and other specimens were collected by KOBAYASHI and myself from *Oxytoma* bed at Higashinakayama (Loc. 9).

Oxytoma inequivalve (SOWERBY)

Plate V, Figures 18, 19: Plate VII, Figure 17

1819, *Avicula inequivalvis* SOWERBY, Min. Conch., Vol. 3, p. 78, pl. 244, fig. 2 (non fig. 3).
1958, *Oxytoma inaequivalvis* ICHIKAWA, *Palaeontogr., Bd. 111*, p. 159, 161*.
non 1959, *Oxytoma* cf. *inequivalve* HAYAMI, *Japan, Jour. Geol. Geogr., Vol. 30*, p. 57, pl. 5, figs. 6–11 (non *inequivalve* SOWERBY)**.

Description of Toyora specimens:—Shell small for genus, pteriform, plano-convex, highly inequivalve, longer than high; left valve moderately inflated with a slightly salient umbonal region above hinge; anterior wing moderate in width, subtrigonal, subvertically truncated; posterior one projected backwards, pointed at extremity, but not protruded beyond posterior extremity of main body; hinge-line moderate in length; umbo located at about a fourth of hinge-length from front; apical angle exclusive of wingth about 90 degrees; surface ornamented with 14 or 15 straight radial primary ribs; secondary median ribs improminent or absent; tertiaries very weak; right valve having numerous faint radial threads and short radial furrows near ventral margin which may interlock with ribs on counter valve; hinge and ligament structures uuknown.

Measurement in mm.	Length	Height	Thickness
(MM 3375) left valve	11.5	8.5	2.0
(MM 3376) left valve	12.0	9.5	3.0
(MM 3377) right in. mould	8.0	5.5	0.5

Observation and comparison:—Three left and four right valves are at hand. The left valves are somewhat variable in shell-obliquity and shell-convexity. But it may be due to an individuality within one species, since those characters generally vary among ontogenetical stages as I noted elsewhere (1959 b). This form is clearly distinguishable from *O. kobayashii* from the same horizon in the weaker inflation of both valves, shorter posterior wing and larger apical angle. It belongs undoubtedly to "Formenkreis der *Oxytoma inaequivalvis*" by WAAGEN (1901) which appears to have lived from the Rhaetic to the Lower Cretaceous. The "Formenkreis" is one of the groups which have given rise to most differences of opinion as to taxonomy and nomenclature among Jurassic pelecypods. WAAGEN (1901), ROLLIER (1914), GILLET (1924), ARKELL (1933), COX (1935, 1940), DECHASEAUX (1938), TROEDSSON (1951) and some others discussed this problem. *Oxytoma münsteri* (GOLDFUSS, 1836), the type-species of the genus, has been regarded by the greater part of these authors as a synonym or merely a varietal

* The synonymy, variability and distinction among *inequivalve, münsteri* and their related forms were discussed.

** The form should be renamed *Oxytoma* cf. *münsteri* (GOLDFUSS) as noted in the post-script of that paper.

from of *O.inequivalve*, until ICHIKAWA (1958) clarified the specific distinction between about European material. ARKELL (1933) disignated the lectotype of *inequivalve* to the specimen (SOWERBY, 1819, pl. 244, fig. 2, left) from the middle Lias of England. "The true *Oxytoma inaequivalvis* from the middle Lias of England has only 14 or 15 primary ribs (counting two minute ones at the anterior end), and there are no median ribs of a secondary order of magnitude in the interspaces, which are covered with very numerous and extremely fine radial threads or riblets (tertiaries)" (ARKELL, 1933, p. 195). ICHIKAWA (1958) examined the "cotypes" of *O. münsteri* and clarified the radial ribbing of three orders of prominence. He said further about *O. inequivalve* (s. s.) preserved in British Museum, "In Bezug auf die radial Skulpture der rechten Klappe ist zu bemerken, dass auch das Original-Handstück des Lectotypus eine rechte Klappe mit ausgesprochen weitständig angeordneten Radialfurchen enthält." The resemblance and differences among *inequivalve*, *münsteri* and two Japanese forms in my mind are shown in table 3.

Table 3. Main characters of typical and Japanese forms of *Oxytoma inequivalve* and *Oxytoma münsteri*.

	characters	*O. inequivalve* typical form (ARKELL, 1933)	*O. inequivalve* present form	*O.* cf. *münsteri* Aratozaki form (HAYAMI, 1959 b)	*O. münsteri* typical form (ICHIKAWA, 1958)
left valve	outline	prosocline	prosocline	variable	very prosocline
	convexity	moderate	moderate	moderate (mature) strong (immature)	strong
	posterior wing	ill-defined pointed	ill-defined pointed	well-defined pointed	well-defined pointed
	umbo	slightly salient	slightly salient	moderately (mature) highly (immature)	highly salient
	primary ribs	14–15	14–15	14–17	12–18
	secondary ribs	absent	improminent	present	present
	dimensions	moderate	small	small	small
right valve	convexity	weak	weak	weak	weak
	ornamentation	faint radial threads	faint radial threads	fine radial striae	radial ribs
	radial furrows	present	present	absent	absent
	age	middle Lias	lower Lias	lower Dogger	middle Dogger

In these respects the Toyora specimens are identical with *O. inequivalve* SOWERBY (inclusive of *O. sinemuriense* D'ORBIGNY, 1850 and *O. intermedium* EMMRICH, 1853, as subspecies), although the dimensions may be somewhat smaller than typical European forms.

This form is different from *O.* cf. *münsteri* in HAYAMI (1959 b) from the Bajocian Aratozaki formation of Northeast Japan in the much weaker shell-convexity, weaker secondaries in left valve and presence of radial furrows near ventral periphery of right valve. As I showed in the synonymic list related to the Aratozaki form, many forms from various Jurassic stages in other areas than Europe have been referred to *inequivalve* or *münsteri*. Which species-group they belong to is difficult to say, unless their right valves occur in association. The peripheral region of right valve seems to tend to be damaged because of the ill-development of nacreous layer and fragile marginal zone of reverse convexity. As to Japanese Jurassic specimens, however, it is now ascertained that the lower Liassic ones are similar to *inequivalve* and the Bajocian ones to *münsteri*. The tendency seems to coincide with the fact about European material.

Occurrence:—Common in *Oxytoma* bed at Higashinagano (Loc. 4) and Higashinakayama (Loc. 9).

Family **Pectinidae** LAMARCK

Genus *Chlamys* RÖDING, 1798

Type-species:—Chlamys cinnabarina RÖDING, 1798, Recent (by HERRMANNSEN, 1846).

Chlamys textoria (SCHLOTHEIM)

Plate V, Figures 23–26

1820, *Pecten textorius* SCHLOTHEIM, Petrefactenkunde, p. 229.
1836, *Pecten textorius* GOLDFUSS, Petref. Germ., Bd. 2, p. 45, pl. 89, figs. 9a–d.
1836, *Pecten texturatus* GOLDFUSS, *Ibid.*, p. 45, pl. 90, fiig. 1.
1850, *Pecten phillis* D'ORBIGNY, Prodrome, I, p. 257.
1850, *Pecten textorius* D'ORBIGNY, *Ibid.*, I, p. 219.
1853, *Pecten textorius* CHAPUIS and DEWALQUE, *Mém. cour. Séance, Tom. 25*, p. 209, pl 32, fig. 2.
1855, *Pecten texturatus* TERQUEM, *Mém. Soc. géol. France, Sér. 2, Tom. 5*, p. 104.
1856, *Pecten textorius* QUENSTEDT, Der Jura, p. 78, pl. 9, fig. 12; p. 147, pl. 18, fig. 17; non p. 500, pl. 67, fig. 5.
1856, *Pecten textorius-torulosi* QUENSTEDT, *Ibid.*, p. 311, pl. 42, fig. 10.
1856, *Pecten textorius* OPPEL, Die Juraformation, p. 223.
1863, *Pecten textorius* SCHLOENBACH, *Zeit. deut. geol, Gesell., Bd. 15*, p. 543.
1865, *Pecten textorius* BRAUNS, *Palaeontogr., Bd. 13*, p. 121.
1867, *Pecten textorius* DUMORTIER, Études pal. Dép. jura. Bassin de Rhône, II, p. 71, pl. 13, fig. 1.
1868, *Pecten textorius* TERQUEM and PIETTE, *Mém. Soc. géol. France, Sér. 2, Tom. 8*, p. 103.
1868, *Pecten texturatus* TERQUEM and PIETTE, *Ibid., Sér. 2, Tom. 8*. p. 104.
1869, *Pecten textorius* DUMORTIER, Études pal. Dép. jura. Bassin de Rhône, III, p. 139, pl. 22, fig. 2; p. 303, pl. 39, figs. 1, 2.
1871, *Pecten textorius* BRAUNS, Der untere Jura, p. 387.
1872, *Pecten textorius* (*olifex*) FRITZGARTNER, Die Pentacriniten, p. 33.
1874, *Pecten textorius* DUMORTIER, Études pal. Dép. jura. Bassin de Rhône, IV, p. 199, pl. 44, fig. 12.
1890, *Pecten* (*Chlamys*) *textorius* PARONA, *Atti. Soc. Ital. Sci. Nat., Vol. 33*, p. 83, pl. 1, figs. 11, 12.
1891, *Pecten textorius* BEHRENDSEN, *Zeit. deut. geol. Gesell., Bd. 43, Pt. 1*, p. 389.

1894, *Pecten textorius* MÖRICKE, *N. Jahrb. f. Min. usw.*, *BB. 9*, p. 37.
1900, *Pecten textorius* PHILIPPI, *Zeit. deut. geol. Gesell.*, *Bd. 52*, p. 86.
1902, *Pecten textorius* JENENSCH, *Abh. geol. Spezialk. Elsass-Lotha.*, *N. F.*, *Bd. 5*, p. 17.
1903, *Pecten textorius* BURCKHARDT, *Palaeontogr.*, *Bd. 50*, p. 7.
? 1905, *Pecten textorius* BENECKE, *Abh. geol. Spezialk. Elsass-Lothr.*, *N. F.*, *Bd. 6*, p. 111, pl. 5, figs. 1, 2.
1904, *Pecten textorius* WUNSTORF, *Jahrb. preuss. geol. Landes.*, *1904*, p. 516.
1908, *Pecten* (*Chlamys*) *textorius* TRAUTH, *Mitt. geol. Gesell. Wien*, *Bd. 1*, p. 451
1912, *Pecten textorius* POELMANN, Jura von Hellern, p. 37.
1914, *Pecten textorius* JAWORSKI, *N. Jahrb. f. Min. usw.*, *BB. 37*, p. 285.
1915, *Pecten textorius* JAWORSKI, *Ibid.*, *BB. 40*, p. 437.
1915, *Pecten textorius* var. *torulosa* JAWORSKI, *Ibid.*, *BB. 40*, p. 437.
1920, *Pecten* (*Chlamys*) cf. *textorius* JAWORSKI, *Jaarb. Mijnb. Ned. Oost-Indie*, *49e jaarg. Verhand. 2*, p. 194, pl. 1, fig. 1.
1923, *Pecten textorius* HUMMEL, *Palaeontogr.*, *Supple.*, *Bd. 4*, *Lief. 3*, *Abt. 4*, p. 162, pl. 11, fig. 10.
1923, *Pecten torulosus* ERNST, *Palaeontogr.*, *Bd. 65*, p. 52, pl. 1, fig. 8.
1926, *Pecten* (*Chlamys*) *textorius* JAWORSKI, *Actas Acad. Nac. Cienc.*, *Vol. 9. Nos. 3–4*, p. 167.
1926, *Chlamys textoria* STAESCHE, *Geol. Pal. Abh.*, *N. F.*, *Bd. 15*, p. 30.
1926, *Chlamys* aff. *textoriae* STAESCHE, *Ibid.*, *N. F.*, *Bd. 15*, p. 32, pl. 1, figs. 8, 9.
1926, *Chlamys torulosi* STAESCHE, *Ibid.*, *N. F.*, *Bd. 15*, p. 33, pl. 1, fig. 1.
1926, *Chlamys* cf. *phillis* STAESCHE, *Ibid.*, *N. F.*, *Bd. 15*, p. 34, pl. 1, fig. 12.
1931, *Pecten textorius* var. *torulosa* WEAVER, *Mem. Univ. Washington*, *Vol. 1*, p. 271, pl. 28, figs. 165, 166.
1934, *Chlamys textorius* DACQUÉ, Wirbelose der Jura, p. 208.
1936, *Chlamys textorius* DECHASEAUX, *Ann. Paléont. Tom. 25*, p. 13, pl. 1, figs. 1–4.
1936, *Chlamys textorius* JOLY, *Mém. Mus. roy. d'Hist. nat. Belg.*, *Mém. No. 79*, p. 109.
1939, *Chlamys* aff. *textorius* MULLER and FERGUSON, *Bull. Geol. Soc. America*, *Vol. 50*, p. 1611.
1942, *Pecten* (*Chlamys*) *textorius* LEANZA, *Rev. Museo La Plata*, *N. S.*, *Vol. 2*, *No. 10*, p. 172, pl. 7, fig. 2.
1942, *Pecten* (*Chlamys*) *textorius* var. *torulosa* LEANZA, *Ibid.*, *N. S.*, *Vol. 2*, p. 173, pl. 7, fig. 4.
? 1946, *Chlamys textorius* GARDET and GÉRARD, *Prot. Rép. Franç. Maroc*, *Notes et Mém.*, *No. 64*, p. 15, 21.
? 1951, *Chlamys textoria* TROEDSSON, *Kungl. Fysio. Säll. Handl.*, *N. F.*, *Bd. 62*, *Nr. 1*, p. 213, pl. 20, figs. 14–16.
1952, *Pecten* (*Chlamys*) *textorius* KIPARISOVA, *Trans. All Soviet Union*, *Geol. Inst.*, *1952*, p. 17, pl. 4, figs. 1–5.
? 1957, *Chlamys textoria* BERINI, *Ist. Geol. Pal. Geogr. Univ. Milano*, *Ser. P. Publ.*, *No. 92*, p. 42, pl. 3, fig. 2.

Description of Toyora specimens:—Shell medium for genus, acline, inequivalve, subequilateral exclusive of auricles, higher than long; left valve moderately inflated, while inflation of right valve is much weaker; antero-dorsal margin slightly sinuated; postero-dorsal one nearly straight; ventral margin broadly arcuate; hinge-line fairly long, occupying about three-fourths of shell-length, straight; dorsal margin often rising slightly above hinge-line in anterior part of right valve; umbo lying near mid-point of length, pointed with an acute apical angle of about 80 degrees or slightly more; byssal auricle fairly large, protruded, depressed, linguiform, supported by a developed auricular sulcus, forming a profound byssal notch below; left anterior auricle large, about

twice as wide as posterior, triangular, provided with a slightly sinuated anterior margin which corresponds with byssal notch on counter valve; posterior auricle subequal between two valve, comparatively small, obtuse-trigonal, well-defined; surface marked with 65 or more (in adult stage) delicate radial costae and numerous fine concentric fila crossing costae and their interspaces; radials somewhat irregular in strength and breadth, more or less flat-topped in right valve but more angular in left; number of radials increased by irregular bifurcation in right valve and by insertion in left valve; concentric scales undeveloped; auricles including byssal one marked also with several radials and numerous concentric lamellae, though radials become weaker in their upper parts; ctenolium present; resilifer triangular, internal.

Measurement in mm.	Length	Height	Thickness
(MM 3379) right ex. mould	27.0+	34.5	3.0
(MM 3380) right ex. mould	14.0	16.5	1.5
(MM 3381) right ex. mould	12.5	15.5	1.5
(MM 3382) left ex. mould	28.0	27.0+	4.5+

Observation and comparison:—Nine specimens, of which six are right external moulds, are at hand. The left valve is represented by two imperfect specimens. A left external mould is considerably large and have about 70 radials, while they are about 40–55 in most specimens. The external and intereal characters are almost equal to those of *Chlamys* (s. s.), if one ignores the considerable inequivalveness (properly the different convexity between two valves) which is commonly seen in Liassic species.

In the general outline, large anterior auricle, mode of radial ribbing, prominent concentrics and inequivalveness, these specimens are referable to *Chlamys textoria* (Schlotheim), a famous Liassic cosmopolitan species. In comparison with Goldfuss' figures of similar size the radials are evidently larger in number and the posterior auricle is slightly smaller, though these characters are seemingly fairly variable among the figures. In these respects this may be closer to *Pecten texturatus* Goldfuss, 1836, but I consider *texturata* to be conspecific with *textoria* in agreement with many authors. Goldfuss' (1836, pl. 89, fig. 9 a), Benecke's (1905), Leanza's (1942), Troedsson's (1951) and Berini's (1957) specimens of moderate size have only 20–30 radials, and it is doubtful if they are actually conspecific with such a multicostate form as these specimens. I think that the ornamentation of *C. textoria* is fairly variable, as pointed out by Dechaseaux about European specimens. The variability of the number of radials is principally due to the slight differences in the stage of bifurcation or insertion. The apical angle of this form, though it increases slightly through growth, is fairly constant and almost equal to those of European specimens. According to Dechaseaux (1936) *Chlamys textoria* is somewhat long ranged from Hettangian to Toarcian in Paris basin. Quenstedt (1856) and some others assigned some Dogger and Malm specimens to *textoria* or its varieties, but I refer them to *C. dewalquei* or other more advanced species in agreement with Staesch (1926) and Dechaseaux (1936). Those Oolite species have more stout radials and probably less inequivalve shell than *textoria*. Such a tendency is ascertained also between the present form and *Chlamys kobayashii* Hayami, 1959 c, from the Bajocian Tsukinoura and Kosaba formations in Northeast Japan. It can be generally said that

Liassic species of *Chlamys* in Japan have more inequivalve shells (more flattened right valves) than Middle Jurassic and later ones. The tendency well agrees with Cox's statement (1952, p. 4). In the circum-Pacific region *Chlamys textorius* and its comparable forms were recorded from Mexico, Neuquén, Peru, Amur and Taliabu. Although the specific identity cannot always be warranted, *textorius* or its close allies certainly flourished world-widely in Liassic times. Amur specimens illustrated by Kiparisova (1952) show special resemblance to this form, but South American ones seem mainly paucicostate forms.

This resembles *Chlamys kotakiensis* Takai and Hayami, in Hayami (1957e) from the lower (?) Lias of Central Japan in the radial ribbing and inequivalveness. The material of *kotakiensis* is more or less deformed, and its precise comparison with this is difficult. Though I noted before that *kotakiensis* differs from *textoria* by finer radials, the Kuruma and present forms are almost equal in their number. But the apical angle appears slightly larger, radials and concentrics less prominent, byssal auricle smaller, and auricles of left valve worse-defined than the present form. *Chlamys kurumensis* Kobayashi and Hayami and its comparable form in Hayami (1957e) resemble this in the flat right valve but differ in the larger apical angle, more-flat-topped radials and narrower intervals. At a glance *Chlamys similis* Kiparisova, 1954, is similar to this in the outline, but that species is, I presume, a close ally to *Chlamys mojsisovicsi* Kobayashi and Ichikawa, 1949, from the Carnic of Japan which differs from this in the more equivalve shell, smaller byssal auricle and less prominent radials on it. The apical angle is almost equal to that of the type of *mojsisovicsi* from Sakawa basin but slightly smaller than those of Nabae (Nakazawa, 1952), Sakuradani (Ichikawa, 1954a) and Mine specimens.

Occurrence:—Common in *Cardinia toriyamai* bed at Higashinagano (Loc. 5) and rare in *Prosogyrotrigonia inouyei* bed at Higashinagano (Loc. 3).

Genus *Aequipecten* Fischer, 1887

Type-species:—Pecten opercularis Linné, 1758, Recent (monotypy).

"*Aequipecten*" *toyorensis* Hayami, new species

Plate VI, Figures 1–5

Description:—Shell small, subequivalve, equilateral exclusive of auricles, *Chlamys*-like in outline, a little higher than long; both valves strongly inflated, but left valve slightly more convex than right; antero- and postero-dorsal margins of shell-body nearly straight, forming an apical angle of approximately 90 degrees; ventral one subcircular; anterior auricle of right valve comporatively large, protruded, supported by a narrow auricular sulcus; posterior one of each valve subequal, comparatively small, well defined, triangular, subvertically truncated; byssal notch moderate in depth, angular; ornamentation of each valve composed of about 15 stout, highly elevated and non-bifurcated radial costae; radials simple in left valve but in right valve faint grooves and secondary riblets inserted respectively on costae and grooves; byssal auricle marked with three or more weak radials; concentric growth-lines weak and almost indiscernible; internally, radial plications strongly impressed on inner surface near ventral periphery, but umbonal region almost smooth; ctenolium and cardinal crura not observed, probably absent.

Measurement in mm.	Length	Height	Thickness
Holotype (MM 3384) right ex. mould	13.0	14.0	3.0
Paratype (MM 3385) left ex. mould	12.0	13.0	3.5
Paratype (MM 3386) right in. mould	11.0	11.5+	2.0+
Paratype (MM 3387) right in. mould	5.0	5.5	1.0+

Observation and comparison:—Represented by a dozen of specimens. Auricles are mostly broken, but a protruded byssal auricle and byssal notch are clearly observed in the holotype. Judging from the small number of ribs and strong shell-convexity this belongs to "*Aequipecten*" which has been used also for Mesozoic species by many authors. *Radulopecten* ROLLIER, 1911, was deemed by COX (1952) to include some Mesozoic species hitherto referred to *Aequipecten*. *Radulopecten* is defined by about 12 or fewer radial costae whose aspect is quite different between two valves. In this species the shell-convexity is slightly different, but broadly undulated ribs and imbricated concentric scales as seen in that genus are absent. This is morphologically more similar to *Cryptopecten* DALL, BARTSCH and REHDER, 1938 (type: *Cr. alli* DALL, BARTSCH and REHDER, original designation). Such weak secondaries and faint grooves on primaries are sometimes observed also in some living species of *Cryptopecten*. But in *Cryptopecten* the right valve is slightly more inflated than left (HABE, 1951–1953), while it is just the reverse in this species. STAESCHE (1926) and ARKELL (1931) are probably right in insisting that Cenozoic *Aequipecten* is not direct descendants from Mesozoic "*Aequipecten*". COX is also of opinion that true *Aequipecten* appeared at first in the Oligocene. *Pecten priscus* SCHLOTHEIM, 1820 (GOLDFUSS, 1836; TERQUEM and PIETTE, 1868; DUMORTIER, 1867, 1869; STAESCHE, 1926, etc.) from the lower Lias of Europe may be the closest ally to this species. The number of radials and of byssal auricle are quite similar, but the radials of each valve are evidently more flattened at tops and bottoms in this species. *Pecten aequilis* QUENSTEDT, 1858, is conspecific with *priscus* according to DECHASEAUX (1936). *Pecten interstriatus* MÜNSTER in BITTNER (1901) differs from this in the more simple ribs in the right valve. *Pecten lykosensis* KRUMBECK, 1905, from the Upper Jurassic is similar to this in the ornamentation of right valve but different in the smaller number of radials and presence of prominent scales on the radials of left valve. *Chlamys* (*Aequipecten*) *macfadyeni* COX, 1935a, from the Upper Jurassic of British Somaliland has about 19 ribs and they are seemingly more rounded at tops than in this species. *Aequipecten vulgaris* KIMURA, 1951 (TAMURA, 1959b) from the Upper Jurassic Torinosu group in Sakawa, Sakuradani and Sakamoto areas is very similar in many respects, but this is distinguishable from the Torinosu species by the more flat-topped and broader primaries in right valve and the less flabellate outline with a slightly smaller apical angle. The above mentioned species (inclusive of this) are probably congeneric and form a distinct group from *Aequipecten*, *Chlamys* and *Radulopecten*. PHILIPPI (1900a) and STAESCHE (1926) combined such species in the *priscus*-group. DECHASEAUX (1936, p. 86) discussed the relationship between *priscus*-group and *Pseudopecten* BAYLE, 1897 (type: *P. equivalvis* SOWERBY, 1818) and suggested that *Pseudopecten* is a small branch of the *priscus*-group in Sinemurian. The type-species does not agree with this species in the *Patinopecten*-like outline, large apical angle, simple radials and by far larger dimensions. In view of the differences, it is concluded that most species belonging to the *priscus*-group belong to a certain unnamed genus of the

Pectinidae. The generic name of this species is, therefore, provisional.

Occurrence:—Common in *Cardinia toriyamai* bed at Higashinagano (Loc. 5). A specimen in pl. II, fig. 4 from *Prosogyrotrigonia inouyei* bed at Higashinagano (Loc. 4) is unusuary of large size but probably conspecific.

"*Aequipecten*" sp. indet.

Plate V, Figure 27

cf. 1948, *Pecten* (*Aequipecten*) *semiarticulatus?* MENEGHINI in DUBAR, *Notes et Mém. Serv. géol. Maroc, No. 68*, p. 216, pl. 28, Figs. 22–25.

Represented by an imperfect external mould of right (?) valve. Shell medium, slightly inequilateral, moderately inflated (MM 3390, 19.0+mm. long; 18.5+mm. high; 3.0+mm. thick); apical angle about 90 degrees; surface marked with more than 13 stout radial costae, which are faintly curved outwards in anterior (?) part; ribs flattened at tops, but intervals marked with numerous oblique scales; auricles and internal structure unknown.

The differs obviously from the preceding species in the larger dimensions and the presence of many prominent scales between radials. The scales remind one of *Radulopecten*, but the radials are too many. This is probably intimate to *Pecten* (*Aequipecten*) *semiarticulatus*? in DUBAR (1948) from the Domerian of of Morocco with regard to the ornamentation with similar number of radials and fine oblique scales. But further comparison is impossible, since the internal structure, auricles and counter valve are unknown.

Occurrence:—Rare in *Cardinia toriyamai* bed at Higashinagano (Loc. 5).

Family **Amusiidae** RIDEWOOD

Genus *Entolium* MEEK, 1865

(=*Syncyclonema* MEEK, 1864; *Protamussium* VERRILL, 1899)

Type-species:—*Pecten demissus* PHILLIPS, 1829, Dogger to lower Malm, Europe (original designation).

Entolium cf. *calvum* (GOLDFUSS)

Plate VI, Figures 6–9

cf. 1836, *Pecten calvus* GOLDFUSS, Petref. Germ., Bd. 2, p. 74, pl. 99, fig. 1.
cf. 1858, *Pecten calvus* QUENSTEDT, Der Jura, p. 184, pl. 23, fig. 1.
? 1908, *Entolium calvum* THEVENIN, *Ann. de Pal., Tom. 3*, p. 23, pl. 23, fig. 11.
cf. 1926, *Chlamys calva* STAESCHE, *Geol. u. Pal. Abhandl., N. F., Bd. 15, Ht. 1*, p. 58, pl, 2, figs. 11, 12.
cf. 1936, *Entolium calvus* DECHASEAUX, *Ann. de Pal., Tom. 25*, p. 60.
cf. 1936, *Entolium calvus* JOLY, *Mém. Mus. roy. d'Hist. nat. Belg., Mém., No. 79*, p. 108.
1938, *Pecten* (*Syncyclonema*) sp. listed by TORIYAMA, *Jour. Geol. Soc. Japan, Vol. 45, No. 533*, p. 251.
cf. 1951, *Entolium calvum* TROEDSSON, *Kungl. Fysiogr. Sällsk. Handl., N. F., Bd. 62, Nr. 1*, p. 216, pl. 20, figs. 9–13.
cf. 1957, *Entolium* sp. in HAYAMI, *Trans. Proc. Pal. Soc. Japan, N. S. No. 28*, p. 125, pl. 20, fig. 17.

Description of Toyora specimens:—Shell small to medium, inequivalve, inequilateral, trigonally obricular exclusive of auricles, weakly inflated, higher than

long; test thin; antero-dorsal margin and postero-dorsal nearly straight, passing gradually into venter; apical angle between them about 90 degrees or a little less; hinge-line short and straight, although dorsal margins of auricles fairly rise above it in right valve, forming about 220 degrees or more at beak in adult specimens; auricles well defined, depressed, more or less obtusely truncated at corners in each valve; anterior auricle about twice as wide as posterior, slightly projected forwards, forming a shallow byssal notch in right valve, but its anterior margin subvertical in left valve; ctenolium absent; cardinal crura comparatively weak; a pair of straight blunt internal ridges running from umbo to antero- and postero-ventral peripheral regions, forming an angle of about 70 degrees at beak, somewhat weakened near periphery; resilifer subtriangular, internal, bordered by a strong ridge on each side; surface smooth without any strong concentric lamellae; anterior auricle having distinct growth-lamellae.

Measurement in mm.	Length	Height	Thickness
(MM 3391) right in. mould	22.0	25.0	2.5
(MM 3392) left ex. mould	13.5	15.0	2.0
(MM 3393) left in. mould	16.0	17.5	2.0

Observation and comparison:—Many specimens are at hand. The unequal auricles are observed in all specimens. In right valve the dorsal margins of auricles rises above the hinge-line to variable extent, forming internally a ribbon-like structure of *Entolium*-type. The byssal notch is usually present but very variable in depth.

Such a shallow byssal notch and unequal auricles are often seen in Liassic *Entolium* which is distinguished as "*hehlii*-groupe" by DECHASEAUX (1936). STAESCH (1926) considered that *Entolium* is characterized by the absent byssal notch and the subequal auricles, and regard such species as transitional between *Chlamys* and *Entolium*. But many other authors including DECHASEAUX (1936) and TROEDSSON (1951) are of opinion that they are not related to *Chlamys*. The Toyora specimens have a pair of weak internal ridges along the boundaries along antero- and postero-dorsal margins of main body and weak cardinal crura which are commonly seen in *Entolium* and other amusiids but never in the Pectinidae. *Entolium* appeared already in the Triassic, and its ancestral forms are found in *Pernopecten* in the Upper Palaeozoic (NEWELL, 1938). The unequal auricles (often with a slight byssal notch at certain ontogenetical stage) and a pair of internal ridges seem fairly conservative characters from the Carboniferous to Mesozoic entoliids. *Entolium inequivalve* HAYAMI, 1959, from the Upper Jurassic and *E. orbiculare* (SOWERBY) from the Cenomanian have also slight byssal notches especially in their early ontogenetical stages. Therefore, the phylogeny *Chlamys* to *Entolium* in the Lias epoch suggested by STAESCHE (1926) cannot be accepted.

This form is closely related to, if not identical with, *Entolium calvum* (GOLDFUSS) from the lower Lias of Swabia, Paris basin and Scania. Judging from GOLDFUSS' original figure the typical form may have a slightly more elongated outline but this is quite similar to the Swabia and Scania specimens illustrated by STAESCHE (1926) and TROEDSSON (1951) in the general outline of two valves, apical angle, mode of byssal sinuation and unequality of auricles, although no mention was given as to their internal characters. The dimensions may be a little larger than European forms. The auricles are seemingly slightly more protruded up-

wards than in Scania specimens. But their development is probably more or less related to the ontogeny of individuals in the present form. The age of *calvum* is Hettangian in Paris basin (DACQUÉ, 1934; DECHASEAUX, 1936: JOLY, 1936) and early Sinemurian in Scania (TROEDSSON, 1951), and the present form must be nearly coeval with the European ones. This is also similar to *Entolium lundgreni* MOBERG in TROEDSSON (1951) from Scania. TROEDSSON regarded that it is not far apart from *calvum* but different in the shell-sculpture and curvature of umbo. In the weakness of concentric lamellae this is closer to *calvum* than *lundgreni*. *Entolium cingulatum* (GOLDFUSS, 1836) (STAESCHE, 1926; TROEDSSON, 1951) differs from this in the absence of distinct byssal notch and less unequal auricles.

Occurrence:—Common in *Cardinia toriyamai* bed at Higashinagano (Loc. 5) and rare in *Prosogyrotrigonia inouyei* bed at Higashinagano (Loc. 3) and Higashinakayama (Loc. 8). A left (?) valve collected by KOBAYASHI from the Kuruma group at Kamikawara (HAYAMI, 1957e) is comparable with this form.

Entolium cf. *lunare* (ROEMER)

Plate VI, Figure 11

cf. 1839, *Pecten lunaris* ROEMER, Verst. nord. Oolithengebirges, p. 26.
cf. 1871, *Pecten lunaris* BRAUNS, Untere Jura, p. 398.
cf. 1915, *Pecten* (*Entolium*) *lunaris* ROLLIER, *Mém. Soc. pal. Suisse*, p. 469.
cf. 1926, *Entolium lunare* STAESCHE, *Geol. u. Pal. Abh., N. F., Bd. 13, Ht. 1*, p. 96, pl. 4, figs. 1, 2.

Description of Toyora specimens:—Shell medium, equilateral, trigonal-orbicular exclusive of auricles, nearly as high as long; right valve not strongly inflated; antero- and postero-dorsal margins long, slightly sinuated, forming an apical angle of about 115 degrees at beak; auricles small, subequal, obtusely truncated; their dorsal margins fairly rising above hinge-line; byssal notch absent; surface smooth but for faint growth-lamellae; cardinal crura narrow but stout, ridge-like; a pair of strong internal ridges running from beak to antero- and postero-ventral peripheral regions. Left valve unknown.

Measurement in mm.	Length	Height	Thickness
(MM 3396) right ex. mould	22.5	22.0	2.0
(MM 3397) right in. mould	21.0	22.5	2.0

Observation and comparison:—Two specimens are at hand. This form is different from the preceding in the subequal auricles, absence of byssal notch, larger apical angle, sinuated antero- and postero-dorsal margins of main body and presence of strong cardinal crura. Although the dimensions are somewhat small, it is probably a close ally to *Entolium lunare* (ROEMER) from the lower Lias of Europe, in view of the resemblance of outline to STAESCHE's figures. *Pecten demissus* in BENECKE (1905) from the Aalenian show a similar outline to this, but typical *E. demissum* (PHILLIPS) from Middle to Upper Jurassic has probably larger auricles according to STAESCHE (1926) and DECHASEAUX (1936). Besides, *Entolium fossatum* MARWICK, 1953, from the Aratauran (lower Lias) of New Zealand has a similar outline and inner structure, but the auricles of *fossatum* are said to be fairly unequal in size.

Occurrence:—Rare in *Prosogyrotrigonia inouyei* bed at Higashinagano (Loc. 3).

Entolium sp. indet.

Plate VI, Figure 10

A right internal mould differs from above mentioned two forms in the larger dimensions and vertically elongated outline. (MM 3398, 16.0 mm. long; 20.0mm. high; 3.0+mm thick). Anterior auricle is slightly larger than posterior, but byssal notch absent. The produced dorsal margin above hinge and distinct internal ridges from umbo to antero- and postero-ventral perepheries show that this belongs to *Entolium*, but specifically it is indeterminable, since its exterior is unknown.

Occurrence:—Rare in *Oxytoma* bed at Higashinakayama (Loc. 9). KOBAYASHI coll.

Entolium (?) sp. indet.

Plate VI, Figures 11, 12

Represented by an imperfect external and an internal mould of different left valves. Shell small to medium, flabelliform, weakly inflated (MM 3399, left in. mould, 14.0 mm. long; 13.0 mm. high); antero- and postero-dorsal margins slightly sinuated, forming an apical angle of about 120 degrees; auricles unequal; anterior one large, subrectangularly truncated, marked with numerous fine growth-lamellae; posterior one comparatively small, obtusely truncated at corner; surface smooth without any prominent growth-lines.

Since the right valve and detail of internal structure are unknown, it is difficult to say that it belongs actually to *Entolium*. Such a flabelliform outline is somewhat similar to "*Camptonectes*" *subflabelliformis* HAYAMI, 1957 e, and its allies from the Lias of Central Japan. But the shell is much less inflated than the Kuruma forms, though it is probable that this is congeneric with them.

Occurrence:—Rare in *Cardinia toriyamai* bed at Higashinagano (Loc. 5).

Family **Plicatulidae** IREDALE

Genus *Plicatula* LAMARCK, 1801

Type-species:—*Plicatula gibbosa* LAMARCK, 1801, Recent (=*Spondylus plicatus* LINNÉ, 1758) (monotypy).

Plicatula subcircularis HAYAMI, new species

Plate VI, Figures 14–16

Description:—Shell medium for genus, inequivalve, subequilateral, irregular in outline but usually subcircular, weakly inflated, nearly as high as long; not alate, adhering to an object with umbonal area of right valve; ornamentation different between two valves; in right valve surface irregularly undulated, smooth in umbonal area but having quite irregularly disposed small low tubercles on remaining part; in left valve shell-surface not so irregularly undulated, provided with numerous spiny tubercles which are radially arranged and subequal at interval; rows of tubercles never bifurcated but occasionally increasing their number by insertion; hinge moderate in width; right valve having a pair

of subparallel strong crural teeth which are bordered by a pair of deep crural sockets and interrupted by a deeply submerged central pit; left valve having a pair of finely crenulated and elongated crural teeth which form an obtuse chevron of about 120 degrees at beak; resilifer located at upper part of central pit, strongly impressed on right valve but weakly on left; adductor monomyarian, large, orbicular, subcentral; pallial line indistinct.

Measurement in mm.	Length	Height	Thickness
Holotype (MM 3401) left in. mould	19.0	16.5	2.0
Paratype (MM 3402) left ex. mould	14.5+	18.0	2.5
Paratype (MM 3403) right in. mould	25.0	20.5	3.0
Paratype (MM 3404) right ex. mould	13.5	13.0	2.5

Observation and comparison:—Two right specimens and many left ones were obtained. In view of the hinge-structure this is certainly referable to *Plicatula*, but the suborbicular outline is very unique. The large angle between the two crural teeth in left valve reminds one of *Dimya* ROUAULT (type: *D. deshayesiana* ROUAULT, monotypy), but the crural teeth are stout and adductor monomyarian in this species. I could find no comparable species with this in foreign literatures.

Occurrence:—Common in *Cardinia toriyamai* bed at Higashinagano (Loc. 5)

Plicatula praenipponica HAYAMI, new species

Plate VI, Figures 17–19

Description:—Shell large for genus, inequilateral, elongated subvertically, fairly irregular in outline, not alate, often more or less contorted, much higher than long; test fairly thick; hinge-line short, rounded; left valve having numerous irregular, often bifurcated radial riblets on whole surface and a few irregularly disposed spines near ventral margin; mode of ornamentation changed fairly abruptly in middle stage; hinge of right valve symmetrical; resilifer deep, elongated, variable in inclination but usually subvertical, defined from crural sockets on both sides by a pair of subparallel ridges; crural teeth usually stout, elongated, strongly crenulated laterally as if trigoniid's cardinals, apart from beak with narrow flattened areas; adductor monomyarian, suborbicular, strongly impressed, subcentral or slightly posterior; pallial line distinct, entire. Nothing known of right valve.

Measurement in mm.	Length	Height	Thickness
Holotype (MM 3406) left in. mould	27.5	32.0	4.0
Paratype (MM 3407) left in. mould	29.0	36.5	4.5
Paratype (MM 3408) left in. mould	20.0+	38.0	3.5+

Observation and comparison:—Represented by six specimens. The holotype specimen composed of left external and internal moulds shows clearly the surface ornamentation and characteristic dentition. The outline and shell-convexity are quite variable among individuals. A specimens (fig. 17) has a somewhat contorted outline and slightly concave internal surface of ventral area. Another specimen has an opisthocline resilifer and bordered teeth whose inclination is more asymmetrical than other specimens. But these must be conspecific with one,

another, since the hinge-structure and other essential characters are identical.

The hinge of this species appears to be fairly deviated from Recent and most Mesozoic species of *Plicatula*. More precisely, the two crenulated crural teeth are unusually strong, situated apart from the resilifer in left valve and fairly curved along the rounded pre- and post-umbonal margins. Such a peculiar feature of hinge and large dimensions suggest that this belongs to another subgenus than *Plicatula* (s. s.). DESLONGCHAMPS (1859) noted that *Harpax* PARKINSON, 1811, should be retained for certain Mesozoic species. But many other authors considered that they are synonymous. According to STOLICZKA (1871), *Harpax* has generally stronger and more parallel hinge-teeth, often larger size and thick test than *Plicatula*, but that it would not be justifiable to recognize *Harpax* as a distinct genus, since the two are essentially the same in the general characters. On the other hand it is certain that undoubted species of *Plicatula* appeared already in the Lias, for instance, *P. spinosa* SOWERBY in GOLDFUSS (1836). They are so similar to Recent typical *Plicatula* in hinge and external characters that no subgeneric distinction is required. I refer this species tentatively to *Plicatula*, since it is unknown to me whether the type-species of *Harpax* is actually separable from *Plicatula* in a higher category than species or they are synonymous.

Plicatula daharensis DUBAR, 1948, including some varietal forms from the Domerian of Morocco is probably intimate to this in view of similar size, ostreid-like irregular outline, disposition of strong crural teeth and abrupt change of ornamentation in middle stage. But the umbo is not so pointed and the ventral area not so roughly plicated as in the African species. This resembles *Plicatula hekiensis* NAKAZAWA, 1955, from the Carnic Nabae group in the general outline and musculature, but differs in the much larger dimensions and presence of radial ribs and spines on the surface. This is readily distinguishable from the preceding species from the same fossil bed in the larger dimensions, elongated outline, different ornamentation, stronger crural teeth and sockets in left valve.

Occurrence:—Common in *Cardinia toriyamai* bed at Higashinagano (Loc. 5) The scarceness of right valves of this and the preceding species in comparison with left valves may imply that the shells adhered to objects by means of right valves and then only left valves were derived and brought into this shell-bank.

Family **Limidae** D'ORBIGNY

Genus *Lima* BRUGUIÈRE, 1797

(=*Radula* KLEIN, 1753, pre-LINNÉ)

Type-species:—*Ostrea lima* LINNÉ, 1758, Recent (tautonymy).

"*Lima*" sp. indet.

Plate VI, Figure 20

Represented by a small left valve. Shell inequilateral, moderately inflated, higher than long (MM 3410. 9.5mm. long; 11.0mm. high; 2.5mm. thick); surface marked with 16 or slightly more radial costae; secondary costae apparently.

This is referable to *Lima* of wide sense and probably a member of *Pseudolimea* ARKELL, 1926, but its exact generic position is indeterminable, because of ignorance of the internal structure. This is similar to *Lima columbiae* Warren, 1931, from the Lias of British Columbia. *Lima densicosta* QUENSTEDT in TONI, 1912 from the Lias is also similar in the outline but different from this in having

more numerous radials.

Occurrence:—Rare in *Oxytoma* bed at Higashinakayama (Loc. 9). Collected by KOBAYASHI.

Genus *Plagiostoma* SOWERBY, 1814

Type-species:—*Plagiostoma gigantea* SOWERBY, 1814, Lias, Europe (by STOLICZKA, 1871).

Plagiostoma kobayashii HAYAMI, new species

Plate VI, Figures 21–23

Description:—Shell medium for genus, equivalve, inequilateral, gibbose and somewhat *Acesta*-like in outline, with length almost equal to height, not strongly inflated; anterior margin nearly straight or slightly sinuated; posterior one gently arcuate but slightly concave near junction with posterior auricle; dorsal margin forming an obtuse chevron of about 150 degrees at beak; hinge-line straight, moderate in length; umbo lying more or less anteriorly from mid-point of hinge-length, slightly rising above it; apical angle between anterior and posterior margins exclusive of auricles measuring about 90 degrees; anterior umbonal ridge sharp, long, forming an angle of about 50 degrees with hinge; auricles very unequal; anterior one narrow, concave, obtusely truncated, scarcely visible from normal direction to valve-margin; posterior auricle large, obtuse-triangular, flattened, not clearly defined from postero-dorsal surface; surface of main body and posterior auricle ornamented with about 65 radial costae; radials more or less flat-topped, nearly straight, regular in prominence, disposed nearly equidistantly but slightly curved outwards and somewhat roughly spaced in posterior part and auricle; their interspaces almost as broad as costae, weekly striated transversely; growth-lines very weak; lunule* well defined, marked with several weak radials, slightly concave, nearly perpendicular to valve-margin; cardinal area very obtusely triangular, slightly asymmetrical with an anteriorly located summit, provided with a ligament pit which is comparatively large, fairly deep, slightly prosocline and rounded at base; inner surface weakly plicated by impression of radials; musculature unknown.

Measurement in mm.	Length	Height	Thickness
Holotype (MM 3411) right ex. mould	31.5+	29.5+	3.5
Paratype (MM 3412) right in. mould	48.5	50.0+	6.0

Observation and comparison:—Four specimens are at hand, though all are more or less broken. The holotype (fig. 21) is an external mould of left valve, showing regular radial ornaments and posterior auricle. The general outline of this species is presumable from growth-lines on the mould and the paratype. The large ill-defined posterior auricle and general outline reminds one of *Acesta* H. and A. ADAMS, 1858, which survives now in deep seas. Many living and Tertiary species of that genus in Eastern Asia are monographed by OYAMA (1943). The umbo is located very anteriorly and the ligament pit very prosocline in all species of *Acesta*, though the exterior of *Acesta* is almost indistinguishable from *Plagiostoma*. In this point *Acesta* is similar to *Mysidioptera* SALOMON, 1895, and

* COX (1943) introduced the term for the anterior slope (more or less excavated area in front of anterior umbonal ridge), though it is unkown if it is actually homologous to the true lunule in dimyarian pelecypods.

Plagiostoma with an acline or slightly prosocline pit to *Lima* (s. s.). There are several Jurassic species hitherto assigned to *Acesta* (ARKELL, 1932; DECHASEAUX, 1936b), but COX (1952) stated that they seemed to be more related to *Plagiostoma*. Many palaeontologists including COX (1943, 1952) assigned *Plagiostoma* as a subgenus of *Lima*, but I treat here the former as a distinct genus. *Acesta* was probably derived from *Plagiostoma* in Cretaceous and is regarded as its subgenus.

This species is very similar to *Lima* (*Plagiostoma*) *pontonis* LYCETT in MORRIS (1853) (COX, 1943) from the Bajocian of England in the ornamentation and outline, but the umbonal area is less inflated and the intervals of costae slightly broader than that species. This is distinguishable from *L.* (*Pl.*) *semicircularis* GOLDFUSS, 1836 (CHAPUIS and DEWALQUE, 1853; GREPPIN, 1900; COX, 1943) from the Aalenian in the broader interval of radials, narrower main body and larger obliquity between hinge and anterior umbonal ridge (it is about 30 degrees in *semicircularis*). *L.* (*Pl.*) *cardiiformis** in BENECKE (1905) and *L.* (*Pl.*) *ferruginea* BENECKE, 1905, from the Aalenian of eastern Paris basin, which the two are synonymous with each other according to DECHASEAUX (1936b), have more prominent umbo and more widely spaced radial costae. *Lima compressa* TERQUEM, 1855, from the lower Lias, regarded as a *Plagiostoma* by DECHASEAUX, differs from this in the comparatively small posterior auricle and more delicate radials. This may be a close ally to *Lima garlandica* WINKLER, 1886, from the lower Lias of Alps, but the posterior auricle is probably more obtusely truncated and worse defined than this species. *Lima* (*Pl.*) *enormicosta* TAMURA (MS), the main constituent species of "the *Lima*-sandstone fauna" in the Upper Jurassic of Soma area differs from this in the irregular and rough costation and more profoundly excavated lunule.

Occurrence:—Common in *Cardinia toriyamai* bed at Higashinagano (Loc. 5).

Plagiostoma matsumotoi HAYAMI, new species

Plate VI, Figures 24, 25; plate VII, Figures 1–3

Description:—Shell medium to small for genus, gibbose, inequilateral, equivalve, not strongly inflated, almost as long as high; test comparatively thin; anterior margin nearly straight or slightly concave at junction with posterior auricle, broadly arcuate, passing gradually into venter; umbo lying very slightly anteriorly from midpoint of hinge-length, not rising above dorsal margin; apical angle exclusive of auricles about 95 degrees; hinge relatively short; anterior umbonal ridge fairly sharp, long, defining an elongated lunule in its front, forming an angle of about 35 degrees with hinge; anterior gaping, if present, very slight; surface marked with faint concentric growth-lamellae and 65 or a little more weak narrow radial striae which are more or less sinuous, almost effaced in central area and often punctate at bottoms in posterior area; intervals becoming broader towards anterior periphery; posterior auricle ill-defined, obtuse-triangular, comparatively small, marked also with fine radial grooves; lunule excavated, smooth except for coarse growth-lamellae; internally, cardinal area obtuse-triangular, moderate in breadth, provided with a slightly prosocline triangular ligament pit which is situated slightly anteriorly from mid-point; a pair of short crura-like teeth present near both peripheries of hinge area; inner surface and

* COX (1943, p. 183) stated that *P. cardiiformis* SOWERBY is a Great Oolite species misinterpreted by MORRIS and LYCETT.

ventral margin quite smooth; musculature unknown.

Measurement in mm.	Length	Height	Thickness
Holotype (MM 3414) left in. mould	27.5	26.5	3.5
Paratype (MM 3415) left ex. mould	37.5	37.0	5.0
Paratype (MM 3416) right in. mould	34.0	34.0	4.5+

Observation and comparison:—Many specimens show external and internal characters. The holotype (fig. 25) is relatively small, but well preserved, showing complete outline. The faint, sinuous, sometimes effaced radial striae are commonly seen in *Acesta*, but known also in many species of *Plagiostoma*. The presence of crura-like teeth on both lateral sides of hinge area is probably unknown in *Plagiostoma*, but it can be expected that similar teeth will be found in most species of the genus, if the internal structure is carefully examined. Cox (1943) announced the presence of a well developed tooth on the anterior auricle of *Lima* (*Plagiostoma*) *hersilia* d'Orbigny. It may correpond with the anterior tooth in this species. Recent species of *Lima* (s. str.) have also teeth-like projections, though they are generally much weaker.

This resembles the preceding species from the same fossil-bed in the ill-defined posterior auricle, gibbose outline and number of radials. But in *kobayashii* radials are never effaced in the central surface, stronger and clearly impressed on the internal surface, and the posterior auricle larger. The anterior umbonal ridge is more opisthocline in this species. Cox (1943, p. 156) noted that its inclination with regard to the hinge-axis is fairly constant in specimens of the same species, and I take it a diagostic character between the two species. *Lima compressa* Terquem, 1855, from the lower Lias resembles this in the weak radials, but they are more effaced in the central part of this species and the obliquity is smaller than that species. *Lima* (*Plagiostoma*) *aciculata* (Münster) (Arkell, 1932) from the Corallian is similar to this, but the radials seem more densely spaced in the anterior area. This resembles also *L.* (*Pl.*) *amnifera* Wildborne, 1883 (Cox, 1943) from the upper Toarcian, but is distinguishale by the absence of a linear groove in front of anterior umbonal ridge and more effaced radials on the middle surface. *L.* (*Pl.*) *savrassovi* Kiparisova, 1952, from the Lias of Amur may have stouter radial striae.

Occurrence:—Common in *Cardinia toriyamai* bed at Higashinagano (Loc. 5) and rare in *Prosogyrotrigonia inouyei* bed at Higashinagano (Locs. 3 and 6) and Higashinakayama (Loc. 8). Kobayashi collected a similar specimen from *Oxytoma* bed at Higashinakayama (Loc. 9).

Plagiostoma sp. indet.

Plate VI, Figure 26

A small right valve (MM 3420, 18.0mm. 16.0mm. high; 2.5mm. thick) does not agree with either of *Plagiostoma kobayashii* and *P. matsumotoi* in the broader main body and nearly smooth surface. This is anyhow a member *Plagiostoma* but specifically indeterminable.

Occurrence:—Rare in *Oxytoma* bed at Higashinagano (Loc. 9). Collected by Kobayashi.

Genus *Antiquilima* Cox, 1943

Type-species:—*Lima antiquata* Sowerby, 1821, upper Lias, England and Germany (original designation)

Antiquilima nagatoensis Hayami, new species

Plate VII, Figures 4 a–c

Description:—Shell medium in size, inequilateral, linguiform but somewhat opithocline, not strongly inflated, much higher than long; anterior margin sinuated near junction with anterior auricle; posterior margin gently arcuate, passing gradually into venter; dorsal margin forming an subsymmetrical obtuse chevron of about 140 degrees at beak; antero- and postero-dorsal corners angular and obtusely truncated; hinge-line short, defining a broad triangular cardinal area provided with a large subcentral trigonal ligamant pit; anterior umbomal ridge absent at all; lunule not impressed; byssal gaping wide, elongated, occupying greater part of anterior margin; anterior auricle very large, flattenend but its anterior marginal zone fairly thickened; posterior auricle comparatively small, ill-defined from main body, obtusely truncated; surface ornamented with 40 or a little more fine radial costae of primary strength and somewhat irregular growth-lamellae; radials distributed irregularly, sometimes interrupted by growth-lamellae, increasing their number through growth by irregular insertion, much narrower than interspace; secondaries much weaker than primaries even at ventral periphery; anterior auricle marked with strong growth-lamellae, and posterior auricle with several weak radials; hinge edentulous; pallial line simple; radials not impressed on internal surface; inner ventral margin smooth.

Measurement in mm.	Length	Height	Thickness
Holotype (MM 3421) right ex. mould	24.5	33.5	6.5
Paratype (MM 3422) right in. mould	14.0+	21.0+	?

Observation and comparison:—Represented by six specimens. The exterior and interior are well revealed in the holotype composed of external and internal moulds. In the holotype the radials are interrupted by some strong growth-lamellae and their directions are abruptly turned outwards. It is one of original characters instead of an accidental damage, for such a tendency is also found in some related species to this.

The elongated outline, large anterior auricle, wide byssal gape, characteristic radial and concentric markings and other features coincide well with the diagnosis of *Antiquilima* Cox, 1943. *Antiquilima*, based on *Lima antiquata* Sowerby from the Lias of England, was originally proposed as a subgenus of *Lima*, but I regard here it as a distinct genus. The mode of ornamentation and byssal structure of *Antiquilima* seem very different from *Lima* and *Plagiostoma*. On the other hand, the morphological resemblance between *Antiquilima* and *Ctenoides* Mörch, 1853 (type: *Lima scabra* Born, by Stoliczka, 1871) is noteworthy. Compared with the Recent species of *Ctenoides*, it is found that the two genera differ clearly in the shell-inclination, development of anterior auricle and ornamentation. Cox (1943) said "*Antiquilima* is abundant in the Lias and persists into the lower Inferior Oolite, then becoming extinct—a fact which also justifies its separation from Recent *Ctenoides* and suggests that the similarity between the two groups constitutes a case of parallel evolution." In fact, many Lower Cretaceous species

of *Ctenoides* (Woods, 1904, etc.) and a Upper Jurassic one (Kimura, 1951) show clear difference from the Liassic group and many allied characters to Recent species.

This is similar to *Lima* (*Antiquilima*) *antiquata* Sowerby, 1821 (Goldfuss, 1836) and *L.* (*A.*) *cubiferens* Whidborne, 1883 (Cox, 1943), but specifically distinguishable from them by the more densely spaced radial costae and more rounded corner of anterior auricle. *Lima nodulosa* Terquem, 1855, from the lower Lias of Paris basin and Mexico (Jaworski, 1929) shows a similar outline and a wide byssal gape in front of anterior auricle, and probably can be included in *Antiquilima*. But the concentric lamellae are more regular and weaker, and the radials are broader with numerous small tubercles in that species. *Lima praelonga* Martin, 1863, from the lower Lias differs from this in the presence of stout primary radials of smaller number and less oblique main body.

Occurrence : —Rare in *Cardinia toriyamai* bed at Higashinagano (Loc. 5).

Genus *Ctenostreon* d'Eichwald, 1862

Type-species :—Ostrea pectiniformis Zieten, 1832, Dogger, Europe (monotypy)*.

Ctenostreon japonicum Hayami, new species

Plate VII., Figures 5, 6

Description : —Shell small for genus, inequilateral, not strongly inflated, nearly acline but somewhat irregular in outline, more or less higher than long; antero-dorsal margin slightly concave, while postero-dorsal one broadly convex, auricles very unequal; anterior one trigonal with a sigmoidal anterior margin, acutely protruded forwards as *Chlamys*' byssal auricle, strongly marked with erect growth-lamellae; posterior one trigonal, flattened, obtusely truncated; hinge-line rather short; surface of main body ornamented with about 13 roof-like radial plications; growth-lines very weak on main body; internal structure as in normal *Lima;* a large, somewhat elongated, trigonal central pit present; hinge edentulous; byssal gape fairly wide, occupying anterior margin of anterior auricle. Left valve unknown.

Measurement in mm.	Length	Height	Thickness
Holotype (MM 3424) right ex. mould	22.5	24.5+	5.0
Paratype (MM 3425) right ex. mould	26.5	23.0+	5.0

Observation and comparison : —Represented by four right specimens. The holotype (Fig. 5) and paratype (Fig. 6) are fairly different from each other in the development of anterior auricle, but the difference is certainly due to the variability within a species. The *Chlamys*-like protruded anterior auricle is somewhat unfamiliar for limids, but the auricular sulcus is absent and the cardinal area external and triangular with a trigonal pit of limid-type. Judging from the presence of byssal gape and the mode of radial ribbing,** this is an early member of *Ctenostreon*, an aberrant but characteristic limid genus ranging from the Lias to Lower Cretaceous, though the dimensions are considarably smaller than normal species.

* See Cox (1952, p. 63, footnote).

** The radial plications of *Ctenostreon* are about 12 in number according to Arkell's diagnosis of the genus (1932).

Lima tuberculata TERQUEM, 1855, non BROCCHI, 1814,* from the lower Lias of eastern Paris basin and *Ctenostreon terquemi* TATE (ARKELL, 1933)* from the pre-*planorbis* bed of England are nearly coeval with this and similar in the surface ornamentation. However, this is different from the two in the more developed anterior auricle and coarse concentrics on it. This may be more closely allied to *Ctenostreon chlamidiforme* ROLLIER, 1911 (=*Ct. pectiniforme* BENECKE, 1905, non SCHLOTHEIM, 1820) from the Aalenian. The species has also a *Chlamys*-like protruded anterior auricle which is strongly marked with erect growth-lamellae as this species. But the auricle is more triangular with a more pointed antero-dorsal extremity than BENECKE's.

Occurrence:—Rare in *Cardinia toriyamai* bed at Higashinagano (Loc. 5).

Ctenostreon sp. indet.

Plate VI, Figure 27

There is another smaller left specimen composed of external and internal moulds, which is similar to the preceding species in the radial ornamentation. Its dimensions are much smaller (MM 3427, 16.5mm. long; 19.5mm. high; 1.5mm. thick), and may be its juvenile specimen. But it differs from the material of *japonicum* in the opisthocline shell, weaker shell-convexity and smaller anterior auricle without strong growth-lamellae. Since no left valve of *japonicum* is represented, it is now impossible to determine whether this is conspecific with *japonicum* or belongs to another species.

Occurrence:—Rare in *Cardinia toriyamai* bed at Higashinagano (Loc. 5).

Family **Ostreidae** LAMARCK

Genus *Liostrea* DOUVILLÉ, 1904

Type-species:—*Ostrea sublamellosa* DUNKER, 1851, lower Lias, Europe (by DOUVILLÉ, 1904).

Liostrea toyorensis HAYAMI, new species

Plate VII, Figures 7, 8

Description:—Shell medium to large, inequivalve, subequilateral, variable in outline but usually subovate, more or less expanded towards venter, fairly higher than long; left valve strongly inflated; convexity strong especially near ventral periphery; umbonal area not coiled; right valve comparatively flat or weakly inflated; umbo opisthogyrous, lying nearly at mid-length; surface of right valve marked with irregular concentric growth-lamellae; no radial ornaments; ligament area of left valve very wide, laminated; provided with a large trigonal opisthocline pit; in right valve ligament area much narrower and pit smaller; adductor scar strongly impressed in each valve, orbicular, lying slightly posteriorly to center.

Measurement in mm.	Length	Height	Thickness
Holotype (MM 3428) left in. mould	59.0	68.0	14.5+
Paratype (MM 3429) left in. mould	59.0	69.5	13.5+
Paratype (MM 3430) right in. mould	39.0	39.0+	6.0+

* JOLY (1936) pointed out the homonym and renamed the species *Ctenostreon terquemi* JOLY, but the specific name is also preoccupied by *Lima terquemi* TATE from the pre-*planorbis* bed of Somerset which is certainly referable to *Ctenostreon* and may be specifically different from JOLY's.

Observation and comparison : —Represented by three left internal, a right external and two right internal moulds. The outline of this species is probably not so variable as usual in normal ostreids. Judging from the absence of radial plication, general outline and geological occurrence, this is referable to *Liostrea* which has been said to comprise most Jurassic species of non-coiled and non-plicated ostreids. DOUVILLÉ noted that *Liostrea* has less inequivalve shells than Recent *Ostrea* (s. s.), but the difference seems to me somewhat obscure, as pointed by ARKELL (1932) and others. In this species the inflation of left valve is unusually strong for normal species of the genus. The strong convexity near ventral periphery is commonly seen in the three internal moulds, and may be a striking character of this species. In this respect this may be more related to subgenus *Catinula* than *Liostrea* (s. s.). But the umbonal area of left valve is considerably flattened, and *Gryphaea*-like appearance is not recognized.

Occurrence : —Common in *Cardinia toriyamai* bed at Higashinagano (Loc. 5) and rare in the basal conglomerate at Takayama (Loc. 1).

Genus *Lopha* RÖDING, 1798

(=*Alectryonia* FISCHER DE WALDHEIM, 1807; *Alectryonella* SACCO, 1897)

Type-species :—Mytilus crista-galli LINNÉ, 1758, Recent (by DALL, 1898).

Lopha sazanami HAYAMI, new species

Plate VII, Figures 9, 11

Description : —Right valve medium to large, subequilateral, variable in outline, but usually ovate, feebly convex, more or less higher than long; umbo lying submesially; surface marked with numerous lamellose concentric growth-lamellae and about 17 radial plications which become gradually prominent towards ventral periphery and sometimes are bifurcated; umbonal area fairly smooth, nearly flat; right valve having a small triangular ligament pit, narrow ligament area and rather weakly impressed, orbicular and subcentral adductor scar; no crenulation on lateral areas of hinge-plate; nothing known of left valve.

Measurement in mm.	Length	Height	Thickness
Holotype (MM 3432) right ex. mould	58.5	76.5	8.0
Paratype (MM 3433) right in. mould	38.0	45.5	6.0+

Observation and comparison : —Represented by two right external moulds and a right internal. There is another external mould (Pl. III, Fig. 10) which is apparently different from the holotype and other specimens in the weaker growth-lamellae and more angular radial plications. It is unknown whether it is a left valve of this species or belongs to another species. *Lopha* is typically characterized by the strongly angulated radial plicae, and Mesozoic species have, in general, rather narrow outlines and median partings whence plications are divergent on the anterior and posterior slops. The plicated surface of this species reminds one of *Lopha*, but the plications are weaker, more numerous and rounded in comparison with typical *Lopha*. Hence, its reference to *Lopha* is provisional. This is seemingly different from normal Mesozoic species in the broadly ovate outline and absence of median parting. *Ostrea* (s. s.) has also many radials on the surface, but they are much weaker and scarcely plicated except for ventral periphery.

Occurrence:—Rare in *Cardinia toriyamai* bed at Higashinagano (Loc. 5).

Family **Trigoniidae** LAMARCK

Genus *Prosogyrotrigonia* KRUMBECK, 1924

Type-species:—Prosogyrotrigonia timorensis KRUMBECK, 1924, Upper Triassic (Rhaetic ?), Timor (original designation).

Prosogyrotrigonia inouyei (YEHARA)

Plate VII, Figures 12–14

1921, *Trigonia inouyei* YEHARA, *Jour. Geol. Soc. Japan, Vol. 38*, p. 8, pl. 15, figs. 1–2.
1931, *Trigonia inouyei* YEHARA, *Trigoniae* in Japan, p. 22, text-fig.
1954, *Prosogyrotrigonia inouyei* KOBAYASHI, in KOBAYASHI and MORI, *Japan. Jour. Geol. Geogr., Vol. 25, Nos. 3–4*, p. 157, pl. 15, figs. 3–5.

Occurrence:—Common in *Prosogyrotrigonia inouyei* bed at Higashinagano (Loc. 3, 6) and Higashinakayama (Loc. 8), and rare in *Cardinia toroyamai* bed at Higashinakayama (Loc. 5). The specimens from the last locality are much smaller than those from other localities. A specimens from a boulder near Loc. 6 is about 55 mm. in length and unusually large for this species.

Family **Cardiniidae** ZITTEL

Genus *Cardinia* AGASSIZ, 1841*

Type-species:—Unio concinnus SOWERBY, 1821, lower Lias and Rhaetic, Europe, Greenland and Siberia.

Remarks:—As discussed before (HAYAMI, 1958e), *Cardinia* can be classified into several groups on the basis of the outline, umbonal structure and surface-ornamentation. *Concinna*-group, i. e. *Cardinia* (s. s.) is characterized by the elongated outline, undeveloped lunule and weak surface ornaments, and it is not impossible that the group was derived from a different stock from that of *hybrida* and other groups.

Concinna-group

Cardinia orientalis HAYAMI, new species

Plate VII, Figure 1

Description:—Shell large for genus, equivalve, inequilateral, elongate-ovate, not strongly inflated, about 1.7 times as long as high; test thick; antero-dorsal margin slightly sinuated in front of umbo; postero-dorsal margin long, gently curved down to siphonal; apical angle about 120 degrees in external view but actually smaller owing to hidden lunule; ventral margin broadly arcuate without sinuation; curvature of margin strong near anterior and posterior extremities of shell; umbo fairly prosogyrous, but not much protruded above lunule, lying at about a sixth of length from front; lunule probably not deep but clearly defined; escutcheon present, nearly vertical; surface smooth but for several irregular concentric lamellae and numerous growth-lines; cardinal teeth apparently obso-

* The decision of the International Commission on Zoological Nomenclature, Opinion 292.

lete; laterals AI, AII, PI and PII remote, short, gradually strengthened towards lateral sides; adductor impression stout, of *Cardinia*-type, a small pedal scar present above anterior adductor scar; umbonal cavity shallow.

Measurement in mm.	Length	Height	Thickness
Holotype (MM 3439) right in. mould	81.0	47.0	10.0
Paratype (MM 3440) left in. mould	96.5+	96.5	12.5+

Observation and comparison:—Three specimens are at hand. The holotype specimen composed of internal and external moulds shows the hinge, musculature and non-imbricated surface ornaments. This can be included in *concinna*-group with regard to the large size, elongated-ovate outline, unexcavated lunule and weak ornamentation. In most species of *concinna*-group listed before (HAYAMI, 1958e), the shell is twice or more as long as high. In this respect this may be transitional between *concinna*- and *crassissima*-groups. *Cardinia concinna* SOWERBY, 1821, *C. copides* RYCKHOLT, 1850 and *C. hennoquii* TERQUEM, 1855 resemble this, but have more elongated outline. *Cardinia philea* D'ORBIGNY, 1850, from the lower to middle Lias of Europe may be also allied to this. Especially Caucasus specimen described by PČELINCEV (1937) as *C.* cf. *philea* shows similar ornaments and shell-elongation. But typical *philea*, as illustrated by BOULE (1906), has a slightly more elongated shell and less terminal umbo than these specimens.

Occurrence:—Rare in *Prosogyrotrigonia inouyei* bed at Higashinagano (Locs. 3,6)

Hybrida-group

Cardinia toriyamai HAYAMI

1938, *Cardinia* sp. listed by TORIYAMA, *Jour. Geol. Soc. Japan, Vol. 45, No. 533*, p. 251.
1958, *Cardinia toriyamai* HAYAMI, *Jour. Fac. Sci. Univ. Tokyo, Sec. 2, Vol. 11, Pt. 2*, p. 121, pl. 11, figs. 1–11.

Occurrence:—Common in *Cardinia toriyamai* bed at Higashinagano (Loc. 5) and rare in *Prosogyrotrigonia inouyei* bed at Higashinakayama (Loc. 8, TORIYAMA coll.). Several well preserved specimens were amplified from Loc. 5, after the original description of this species had been published. I note then that the ventral margin is slightly sinuated mesially in early stage but the sinuation gradually diminishes later. Such a tendency is, however, not always seen in the newly collected specimens.

Family **Astartidae** GRAY

Genus *Praeconia* STOLICZKA, 1871

(=*Theveninia* ROMAN, 1921)

Type-species:—*Astarte terminalis* ROEMER, 1842, Dogger, Europe (original designation).

Plate VII, Figures 15, 16; Plate VIII, Figures 2–4

Praeconia cf. *tetragona* (TERQUEM)

cf. 1855, *Cardita tetragona* TERQUEM, *Mém. Soc. géol. France, Sér. 2, Tom. 5*, p. 83, pl. 20, figs. 9, 9a.
non 1862, *Cardita tetragona* ETALLON, Lethea Bruntrutana, p. 201, pl. 24, fig. 16.*
non 1872, *Cardita tetragona* LORIOL, *Mém. Soc. Linn. Normandie, Vol. 16*, p. 284, pl. 16, fig. 18.*

* Synonyms of *Praeconia rhomboidalis* (PHILLIPS) according to ARKELL (1934).

cf. 1936, *Praeconia tetragona* JOLY, *Mém. Mus. roy. d'Hist. nat. Belg., No. 79*, p. 127, pl. 2, figs. 5 a–c.

cf. 1937, *Praeconia* sp. ex gr. *tetragona* in PČELINCEV, *Mon. Pal. USSR, Vol. 48*, p. 21, pl. 5, fig. 18.

cf. 1938, *Astarte* (*Theveninia*) aff. *tetragona*? in DUBAR, *Notes et Mém. Serv. géol. Maroc, No. 68*, p. 177, pl. 16, figs. 9 a, b.

Description of Toyora specimens:—Shell small to large, subquardate, equivalve, inequilateral, moderately inflated, expanded postero-ventrally, much longer than high; antero-dorsal margin short, slightly sinuated in front of beak, provided with a small but deeply excavated lunule; postero-dorsal margin long, subhorizontal, turned somewhat abruptly into siphonal; ventral margin straight or slightly concave, oblique to hinge; umbo not prominent, very prosogyrous, subterminal; surface marked with six or more imbricated and widely spaced concentric lamellae and numerous faint growth-lines in adult stage; imbrications much weaker and smaller in number in immature stage; escutcheon elongated, nearly vertical, striated by oblique growth-lamellae; dentition of *Astarte*-type; left valve having to cardinal teeth 2 and 4 b; 2 tubercular, stout; 4b elongated, subhorizontal, gradually weakened posteriorly; right valve having a stout, trigonal cardinal 3b and a weak small 3a formed by thickening of pre-umbonal margin; laterals undeveloped; anterior adductor scar wedge-like, very strongly impressed, but *Myoconcha*-like buttress absent; posterior adductor scar large but comparatively weak; pallial line entire; inner ventral margin weakly toothed; umbonal cavity shallow.

Measurement in mm.	Length	Height	Thickness
(MM 3442) left ex. mould	47.0+	29.0+	8.5+
(MM 3443) left in. mould	41.0	26.0	9.0+
(MM 3444) left in. mould	18.0	12.5	3.5
(MM 3445) right in. mould	18.0	12.0	3.5

Observation and comparison:—Seven specimens are at hand. The first specimen (Pl. IV, fig. 4) is an incomplete external mould, exhibiting the splendidly imbricated surface. The second (fig. 3) is an internal mould of left valve showing the hinge, musculature and ventral dentation. Two other specimens (Pl. III, fig. 15, 16; Pl. IV, fig. 2) are probably young individuals. The ventral margin seems nearly straight in juveniles, while a distinct sinuation is found in adults. The ontogeny can be outlined also from the growth-lines of the first specimen.

Such an imbricated surface and ventral sinuation remined one of a cardiniid, but it is referable to *Praeconia* by the quadrate outline and dentition of *Astarte*-type. *Praeconia* is undoubtedly a distinct genus of the Astaridae, but bears some affinities to the Cardiniidae and Myoconchidae in dentition and musculature. I think that the genus is a Jurassic side branch of the trunk of the Astartidae. Both may have been derived almost simultaneously from preheterodont pelecypods. *Theveninia* was originally used as a subgenus of *Astarte* by ROMAN (1921) and later by DUBAR (1948). The type of *Theveninia* (*Hippodium gibbosum* D'ORBIGNY, upper Lias, original designation) has small size and strongly imbricated, widely spaced concentric lamellae on the surface, and may constitute a distinct group from *Astarte terminalis*. But I think that they are generically inseparable. *Cardita tetragona* TERQUEM, 1855, from the lower Lias of Paris basin, which was

later correctly referred to *Praeconia* by JOLY (1936), is very similar to this in the above mentioned characters, although the dimensions of these specimens are often large for that species. The first specimen has much stronger concentric lamellae than TERQUEM's and JOLY's figures, while the surface-markings of smaller specimens are almost identical with them. As to the outline this has a slightly more strongly curved anterior margin, but it is doubtful that such a slight difference is worthy of a specific distinction. *Praeconia* sp. ex gr. *tetragona* in PČELINCEV (1937) and *Astarte* (*Theveninia*) aff. *tetragona*? in DUBAR (1948) are also comparable with this. *Astarte* (*Theveninia*) *gibbosa* (D'ORBIGNY) in ROMAN (1921) from the Bajocian of France differs in the more inflated and much smaller shell.

Occurrence:—Common in *Cardinia toriyamai* bee at Higashinagano (Loc. 5).

Genus *Astarte* SOWERBY, 1817

(=*Crassina* LAMARCK, 1819)

Type-species:—*Astarte lurida* SOWERBY, 1817, Upper Lias and Dogger, Europe (by STOLICZKA, 1871).

Astarte a sp. indet.

Plate VII, Figure 17

Represented by an internal mould of right valve. Shell very small, inequilateral, moderately inflated, longer than high (MM 3447, right internal mould, 6.5 mm. long; 6.0 mm. high; 1.5+mm. thick), trigonally orbicular in outline; antero-dorsal margin fairly sinuated in front of umbo, rather short; postero-dorsal margin long, nearly straight; ventral one subsymmetrically arcuate; umbo very prosogyrous, acute, lying at about a third of length from front; right valve having a strong, triangular cardinal 3b and elongated weak 5b; cardinal sockets 2′ and 4b′ distinct; laterals obsolete; inner ventral margin marked with about 35 transverse crenules; exterior unknown.

This is safely referred to *Astarte* (s. l.) in view of the dentition, prosogyrous umbo and mode of marginal crenulation. In the absence of distinct 3a this is seemingly more related to subgenus *Nicaniella* CHAVAN, 1945, than *Astarte* (s. s.) This is probably a new form, but the specific identification is still deferred untill its exterior is known.

Occurrence:—Rare in *Cardinia toriyamai* bed at Higashinagano (Loc. 5).

Astarte b sp. indet.

Plate VIII, Figures 5a, b

A solitary specimen composed of left internal and external moulds is at hand. Shell small, inequilateral, weakly carinated posteriorly,well inflated, much longer then high (MM 3448, left internal mould, 7.5 mm. long; 6.0 mm high; 2.0 mm. thick); posterior margin fairly abruptly turned into venter at postero-dorsal and postero-ventral corners; surface marked with somewhat irregular and coarse concentric lines; inner ventral margin marked with some 30 transverse crenules which are more roughly spaced in posterior part than in anterior; hinge unknown; adductor impressions weak for astartid.

In the presence of ventral crenules this resembles the preceding form, but

the outline is more quadrate and the crenules are more widely spaced in the posterior part than that form. The small size and outline are at a glance similar to *Prorokia* BOEHM, 1883 (type : *Cardita ovalis* QUENSTEDT, 1852, Malm, Europe, original designation), such as *Prorokia rustica* (LYCETT, 1863) (COX and ARKELL, 1948) from the British Great Oolite series. The mode of shell-convexity is, however, not typical of *Prorokia*. This is very similar to DUMORTIER's figure (1874) described as *Astarte lurida* in the outline and surface-markings, but typical *A. lurida* SOWERBY seems to me less quadrate in outline.

Occurrence :—Rare in *Cardinia toriyamai* bed at Higashinagano (Loc. 5.).

Family **Fimbriidae** NICOL

Genus *Fimbria* MEGERLE, 1811

(=*Corbis* CUVIER, 1817)

Type-species :—*Fimbria magna* MEGERLE, 1811, Recent (=*Venus fimbriata* LINNÉ, 1758) (monotypy).

Fimbria sp. indet.

Plate VIII, Figure 9

Only a fragmental external mould is at hand (MM 3449). Whether it is right or left is unknown. Shell small for genus, ovate, longer than high ; surface marked with more than 13, narrow, equidistant, raised, not sinous concentric ribs and numerous fine interstitial radial threads ; radials somewhat weakened laterally. Judging from the characteristic ornamentation, it is referable to *Fimbria* which is considered as an element of warm sea. It may be the earliest representative of the genus.

Occurrence :—Rare in *Cardinia toriyamai* bed at Higashinagano (Loc. 5.).

Genus *Sphaeriola* STOLICZKA, 1871

Type-species :—*Cardium madridi* D'ARCHIAC, 1842, Bathonian, Europe (original designation).

Sphaeriola nipponica HAYAMI, new species

Plate VIII, Figures 10–13

Description :—Shell medium to fairly large for genus, equivalve, subequilateral, globose in outline with length more or less in excess of height, well inflated ; the greatest convexity lying subcentrally or slightly posteriorly ; test pronouncedly thick in full-grown stage ; shell-margin gently arcuate without any striking angulation or sinuation, though antero-dorsal corner sometimes obtusely angulated ; siphonal margin not clearly defined from postero-dorsal and ventral ; postero-dorsal margin a little longer than antero-dorsal ; umbo slightly prosogyrous, recurved, rising highly above hinge-margin, lying submesially ; surface smooth except for numerous fine concentric growth-lines ; hinge somewhat *Schafhäutlia*-like, consisting of two cardinals in each valve ; right valve having strong cardinals 3a and 3b which are subsymmetrically disposed, imcompletely differentiated from each other and form an obtuse chevron of about 100 degrees at beak ; left valve having a nearly acline tubercular cardinal 2 and narrow elongated 4a ; the

former interrupted from beak by a continuous and chevron-like cardinal socket 3a′–3b′; the latter formed by a thickening of pre-umbonal margin, ill-defined from it; lateral teeth undeveloped, although sometimes a small elevation is seen on posterior hinge area of right valve; lunule absent or, if present, very small; escutcheon very narrow but well marked; ligament opisthodetic, external; adductor impressions subequal, slightly elongated subvertically but very weakly impressed; pallial line obscure but certainly entire; inner ventral margin quite smooth.

Measurement in mm.	Length	Height	Thickness
Holotype (MM 3450) right in. mould	24.5	22.5	9.0
Paratype (MM 3451) right in. mould	44.0	44.0	12.5
Paratype (MM 3452) left in. mould	31.5	31.5	10.0
Paratype (MM 3453) left ex. mould	21.5	19.5	6.0

Observation and comparison: —Many specimens are available for study. The chevron-like hinge-structure is seen in the holotype and other internal moulds. Large specimens show stronger shell-convexity than small ones; and it is probably due to shell-thickening in gerontic stage. The hinge-structure and the presence of lateral-like projection at the posterior hinge area of right valve bear some affinities to *Fimbria* MEGERLE, 1811, but the shell-surface is almost smooth and lack any radial and concentrics ribs. The globular outline with strong convexity, smooth surface and hinge-teeth including the chevron-like 3a–3b and weak subhorizontal 4a are closer to those of *Sphaeriola* STOLICZKA. According to STOLICZKA (1871), *Sphaeriola* is readily distinguishable from *Fimbria* by the absence of lateral teeth and more globular outline. The lateral-like projection in this species is weak and even invisible, and it cannot be warranted that it is actually homologous with the posterior lateral of normal heterodont pelecypods. Such strongly inflated shells with chevron-like cardinals are known as *Schafhäutlia* COSSMANN, 1897 (=*Gonodon* SCHAFHÄUTL, 1863; *Gonodus* WÖHRMANN, 1893) in the Triassic. The type-species of *Schafhäutlia* (*Isocardia ovata* MÜNSTER in GOLDFUSS, 1836) is an Oolitic species, but the greater development of the genus is seen already in the Triassic. Unfortunately, I could not observe the hinge structure of either the type-species or Japanese Triassic species, but the dentition of several Triassic species was clearly illustrated by BITTNER (1895, 1901), FRECH (1907) and DIENER (1925). The cardinal teeth 3a and 3b in right valve are ill-differentiated and united beneath the umbo in Triassic *Schafhäutlia*, but in *Sphaeriola* and this species the chevron is not so obtuse as in that genus. The subhorizontally elongated cardinal 4a of this species is not so developed as typical *Sphaeriola* in D'ARCHIAC's figure. In this respect it may be transitional between Triassic *Sphafhäutlia* and Jurassic *Sphaeriola*.

It is very similar in the hinge, if the undeveloped cardinal 4a is ignored, to *Sphaeriola madridi* (D'ARCHIAC, 1842) (LAUBE, 1867; ROLLIER, 1913) from the Dogger of Western Europe, the type of the genus. But concentric lines are much weaker in the present species. In this point it may be more closely related to *Sphaera madridi* in MORRIS and LYCETT (1853) from the Great Oolite, which should be referred to *Sphaeriola oolithica* (ROLLIER, 1913) according to COX and ARKELL (1948, 1950). It is, however, characterized still more delicate concentrics, more rounded antero- and postero-dorsal margins and smaller apical angle. *Sphaeriola leedae* MARWICK, 1953, from the Aratauan (lower Lias) of New Zea-

land is nearly coeval but differs from it in the more inequilateral outline and more differentiated cardinal 3a and 3b. *Corbis* (*Sphaeriola*) *sibirica* KIPARISOVA, 1952, from the Lias of Amur is also similar to it, but the umbo is more salient in that species. Its further comparison with the Amur species is impossible, since the hinge is unknown.

Occurrence:—Common in *Cardinia toriyamai* bed at Higashinagano (Loc. 5.).

Family **Lucinidae** FLEMING

Genus *Lucina* LAMARCK, 1799 (sensu lato)

Lucina (s. l.) *hasei* HAYAMI, new species

Plate VIII, Figures 6–8

Description:—Shell small for lucinid, inequilateral, suborbicular, well inflated, nearly as long as high; post-umbonal margin nearly straight, forming an apical angle of about 100 degrees with slightly sinuated pre-umbonal margin, fairly abruptly turned into siphonal margin; ventral margin symmetrically arcuate; umbo prominent, prosogyrous, rising highly above dorsal margin; surface ornamented with strongly imbricated concentric lamellae whose intervals become gradually broader towards venter; hinge of lucinoid type, composed of two cardinals and a pair of isolated short laterals in each valve, though 3a is embryonal and often indiscernible; escutcheon clearly defined; lunule narrow but strongly impressed; anterior adductor scar strongly impressed and fairly elongated downwards; posterior one subovate; pallial line distinct, entire, close to ventral margin; inner ventral margin smooth without crenulations.

Measurement in mm.	Length	Height	Thickness
Holotype (MM 3455) left ex. mould	8.5	8.5	3.5
Paratype (MM 3456) right ex. mould	11.0	10.5	3.0+
Paratype (MM 3457) right ex. mould	9.0	8.5	3.0
Paratype (MM 3458) right in. mould	7.5	7.0	2.5

Observation and comparison:—Many specimens are at hand. The holotype (figs. 7a, b) composed of external and internal moulds reveals concentric ornamentation and muscle structure. The exterior with such a strong ornamentation reminds one of a certain astartid especially *Eriphylopsis* MEEK, 1876, but the concentrics are strongly imbricated and the musculature is clearly of *Lucina*-type. It cannot, however, be a typical *Lucina*, since *Lucina* (s. s.) is characterized by an almost edentulous hinge. A comprehensive study of fossil lucinids was undertaken by CHAVAN (1937–1938), but the dentition and musculature of Jurassic species are not as yet sufficiently clarified. CHAVAN is of opinion that subgenus *Callucina* DALL, 1901, of *Lucina* is present already in the Jurassic and several Oolite species belong to the subgenus. In the undeveloped cardinal 3a and presence of short laterals, this is fairly similar to the subgenus. But the cardinals are so stout and concentric lamellae so strongly imbricated that I hesitate to apply the subgeneric name to it. Externally it is somewhat similar to young specimens of *Prosogyrotrigonia inouyei* (YEHARA) from the same bed, but readily distinguished by the more prominent umbo, continuous and imbricated concentrics and presence of a distinct lunule. In the ornamentation this is at a glance akin to some specimens of *Eomiodon vulgaris* HAYAMI, 1958, from various horizons of Lias in

Northeast and Central Japan, but distinguishable from it by the less elongated shell, smaller lunule and different mode of occurrence, even if their hinges are not observable.

Occurrence:—Common in basal conglomerate at Takayama (Loc. 1) and in *Cardinia toriyamai* bed at Higashinagano (Loc. 5).

Family **Cardiidae** Lamarck

Genus *Cardium* Linné, 1758 (sensu lato)

Cardium (s. l.) *naganoensis* Hayami, new species

Plate VIII, Figures 14, 15

Description:—Shell small to medium, equivalve, subequilateral, elliptical, moderately inflated, much longer than high; test moderate in thickness; antero-dorsal margin a little concave; postero-dorsal one nearly straight; ventral one broadly arcuate; the greatest convexity lying near center of valve; umbo slightly prosogyrous, submesial, rising slightly above hinge-margin; surface smooth except for faint concentric lines of growth; no trace of posterior radial ribbing present, but inner ventral margin marked with numerous fine transverse crenules; dentition of cyclodont-type; right valve having two conical cardinals 3a and 3b and a pair of isolated laterals which are symmetrically elongated along antero- and postero-dorsal margins; musculature unknown.

Measurement in mm.	Length	Height	Thickness
Holotype (MM 3461) right in. mould	21.5	17.5	5.0
Paratype (MM 3462) left in. mould	29.0	23.5	6.0

Observation and comparison:—Represented by three specimens. The holotype composed of right external and internal moulds exhibits the smooth surface and dentition of cardiid-type. The ventral crenules may imply the presence of radial ribbing, but they are, if present, much weaker than growth-lines. It is considered as a member of cyclodonts, but the generic position is uncertain. So far as I am aware, most Jurassic cardiids belong to *Protocardia* or *Pterocardia*, and no allied species is found in foreign literatures. Several Jurassic species hitherto referred to *Cardium* have distinct radial ornaments. This may belong to a certain unnamed genus of the Cardiidae, and its generic referrence to *Cardium* (s. l.) is provisional.

Occurrence:—Rare in *Cardinia toriyamai* bed at Higashinagano (Loc. 5).

Genus *Protocardia* Beyrich, 1845

Type-species:—*Cardium hillanum* Sowerby, 1812, Cretaceous, England (by Herrmannsen, 1847).

Protocardia onoi Hayami, new species

Plate VIII, Figures 16–18

Description:—Shell small, fairly inequilateral, subtrigonal, well inflated, more or less longer than high; posterior carination fairly sharp but gradually weakened towards postero-ventral periphery; umbo submesial, orthogyrous, rising highly

above hinge-margin; radial ribs about 23 in number, distributed not only in posterior area but 3 or 4 also in front of posterior carination, gradually weakened towards anterior; whole surface marked with numerous faint growth-lamellae, but concentric ribs absent; left valve provided with a pair of short lateral teeth subparallel to pre- and post-umbonal margins; cardinal teeth and musculature not observed.

Measurement in mm.	Length	Height	Thickness
Holotype (MM 3463) left ex. mould	14.0	13.0	4.5+
Paratype (MM 3464) left in. mould	15.0	12.5	?

Observation and comparison:—Four specimens are at hand. The holotype composed of left external and internal moulds shows radial ornaments of *Protocardia*-type. The most anterior radial rib does not coincide with the posterior carination in this species. It is somewhat similar to *Protocardia contusa* HEALEY, 1908, from the Napeng beds of Upper Burma and to *P. kurumensis* HAYAMI, 1958d, from the Domerio-Toarcian of Central Japan. But it is different from the former in the larger number of radials and the more obscure boundary of their distribution, and from the latter in the absence of prominent concentric ornamentation on the anterior and middle parts of shell-surface. *Protocardia rhaetica* (MERIAN) (MOORE, 1861; ARKELL, 1933; TROEDSSON, 1951) and *P. phillipiana* DUNKER, 1851 (QUENSTEDT, 1858) from the Rhaeto-Lias of Europe, which have been often treated as a single species, differ from this in the more wide-spaced radials and more postero-ventrally expanded outline.

Occurrence:—Rare in *Cardinia toriyamai* bed at Higashinagano

Family **Pleuromyacidae** ZITTEL

Genus *Pleuromya* AGASSIZ, 1843

Type-species:—*Mya gibbosa* SOWERBY, 1825, Upper Jurassic, Europe (by HERRMANNSEN, 1847)

Pleuromya sp. indet.

Plate VIII, Figure 19.

All ill-preserved internal mould of left valve (MM 3467, 13.0mm. long; 7.5 mm. high) is referable to *Pleuromya* from the outline, though specifically indeterminable.

Occurrence:—Rare in *Prosogyrotrigonia inouyei* bed at Higashinagano (Loc. 3).

Incertae sedis

Genus and species indet. a

Plate VIII, Figure 21

A right internal mould is at hand (MM 3468, 29.5mm. long; 23.5mm. high 7.0+mm. thick). Shell medium, trigonally ovate with straight pre- and post-umbonal margins, elongated posteriorly, moderately inflated; test probably thick; hinge composed of a slightly prosocline triangular cardinal tooth which is border-

ed on each side by a triangular socket; adductor scars very large and strongly impressed; pedal scar distinctly marked above anterior adductor; pallial line distinct, entire; test sharply truncated at ventral margin, which is marked with numerous transverse crenules. This bears some alliance to the Astartidae in the large adductor scars and other muscle features, but differs from them tolerably in the dentition and outline.

Occurrence:—Rare in *Cardinia toriyamai* bed at Higashinagano (Loc. 5).

Genus and species indet. b

Plate VIII, Figure 20

Represented by three specimens. Shell medium, equivalve, subequilateral, subrhomboidal to orbicular in outline, much longer than high (MM 3469, right in. mould, 42.0mm. long; 31.0mm. high; 6.5mm. thick); antero-dorsal margin broadly excavated, while postero-dorsal is nearly straight; lunule elongated but narrow; umbo slightly prosogyrous, submesial; hinge-composed of two small cardinal teeth in each valve having an isolated anterior lateral tooth; ventral margin smooth; surface smooth but for growth-lines. It seems to belong to the Superfamily Lucinaceae, but, so far as I am aware, there is no generic name suitable for this form.

Occurrence:—Rare in *Cardinia toriyamai* bed at Higashinagano (Loc. 5).

References

Many references cited in the preceding paper (HAYAMI, 1958e, pp. 127–130) and only in the synonymies are omitted here.

D'ARCHIAC, A. (1842), Description géologique de départment de l'Aisne. *Mém. Soc. géol. France, Sér. 1, Tom. 5.*

ARKELL, W. J. (1926), Studies in the Corallian Lamellibranch Fauna of Oxford, Berks, and Wilts. 1. Limidae. *Geol. Mag., Vol. 63, No. 5.*

——— (1929–1937), A Monograph of British Corallian Lamellibranchia. *Palaeontogr. Soc. London.*

——— (1930), The generic Position and Phylogeny of some Jurassic Arcidae. *Geol. Mag., Vol. 67, Nos. 7 and 8.*

——— (1933), The Jurassic System in Great Britain. *Oxford.*

——— (1956), Jurassic Geology of the World. *Edinburgh.*

BAYLE, M. M. and COQUAND, H. (1850), Mémoire sur les Fossiles secondaires recueillis dans le Chili. *Mém. Soc. géol. France, Sér. 2, Tom. 4.*

BENECKE, E. W. (1905), Die Versteinerungen der Eisenerzformation von Deutsch-Lothringen und Luxemburg. *Abhandl. geol. Spezialk. Elsass-Lothr., N. F., Heft 6.*

BERINI, L. (1957), Studi paleontologici sul Lias del Monte Albenza (Bergamo). Lamellibranchi e gastropoi del Lias inferiore. *Ist. Geol. Pal. Geogr. Univ. Milano, Ser. P, No. 92.*

BITTNER, A. (1895), Lamellibranchiaten der alpinen Trias. *Abhandl. geol. Reichsanst., Bd. 18, Heft 1.*

——— (1901), Lamellibranchiaten aus der Trias des Bakonyerwaldes. *Result. wissensch. Erforsch. Balatonsees, Bd. 1, Teil 1.*

BODEN, K. (1911), Die Fauna des Unteren Oxford von Popilany in Lithauen. *Geol. u. Pal. Abhandl. Jena, N. F., Bd. 10.*

BRANSON, C. (1942), *Paralleloden*, *Grammatodon*, and *Beushausenia* (=*Cosmetodon*, new name). *Jour. Pal., Vol. 16, No. 2.*

CHAVAN, A. (1937–1938), Essai critique de Classification des Lucines. I–IV. *Jour. Conchyl., Vol. 81–82.*

——— (1945), Les Lamellibranches hétérodontes des sables Astartiens de Cordebugle (Calvados). *Ibid., Vol. 86.*

COSSMANN, M. (1897), Revue critique Paléozoologie, 1. *Paris.*

——— (1925), Sur quelques pélécypodes du Jurassique français. *Bull. Soc. géol. France, Sér. 4, Tom. 24.*

COX, L. R. (1930), On British Fossils named by William SMITH. *Ann. Mag. Nat. Hist., Ser. 10, Vol. 6.*

——— (1935), Jurassic Gastropoda and Lamellibranchia. *The Mesozoic Palaeontology of British Somaliland.*

——— (1936), The Gastropoda and Lamellibranchia of the Green Ammonite Beds of Dorset. *Quart. Geol. Soc. London, Vol. 92, Pt. 4.*

——— (1937), Notes on Jurassic Lamellibranchia. II. On *Indogrammatodon*, a new Subgenus from the Jurassic of the Indo-African Province. *Proc. Malacol. Soc. London, Vol. 22, Pt. 4.*

——— (1940), The Jurassic Lamellibranch Fauna of Kuchh (Cutch). *Pal. Indica, Ser. 9, Vol. 3, Pt. 3.*

——— (1941), Notes on Jurassic Lamellibranchia. VII. On the Identity of *Echinotis* MARWICK with *Meleagrinella* WHITFIELD. *Proc. Malacol. Soc. London, Vol. 24.*

——— (1943), The English Upper Lias and Inferior Oolite Species of *Lima. Ibid., Vol. 25, Pts. 5–6.*

——— (1944), On *Pseudolimea* ARKELL. *Ibid., Vol. 26, Pts. 2–3.*

——— (1952), The Jurassic Lamellibranch Fauna of Cutch (Kachh). *Pal. Indica, Ser. 9, Vol. 3, Pt. 4.*

——— and ARKELL, W. J. (1948, 1950), A Survey of the Mollusca of the British Oolite Series. Pts. 1 and 2. *Palaeontogr. Soc. London.*

DECHASEAUX, C. (1936 a), Pectinidés jurassiques de l'Est du Bassin de Paris. *Ann. Paléont., Tom. 25.*

——— (1936 b), Limidés jurassiques de l'Est du Bassin de Paris. *Mém. Mus. roy. d'Hist. nat. Belgique, Sér. 2, Fasc. 8.*

——— (1938), *Oxytoma* jurassiques de Lorraine. *Jour. Conchyl., Vol. 82.*

DIENER, C. (1925), Leitfossilien der Trias. *Berlin.*

DOUGLAS, J. A. and ARKELL, W. J. (1932), The stratigraphical Distribution of Cornbrash: II. The Northeastern Area. *Quart. Jour. Geol. Soc. London, Vol. 88.*

DOUVILLÉ, H. (1912), Classification des Lamellibranches. *Bull. Soc. géol. France, Sér. 4, Tom. 12.*

DUBAR, G. (1948), La Faune domérienne du Djebel Bou-dahar. *Notes et Mém. Serv. géol. Maroc, No. 68.*

DUMORTIER, E. (1874), Études paléontologique sur les Dépots jurassiques du Bassin du Rhône. IV. Lias supérieur. *Paris.*

ERNST, W. (1923), Zur Stratigraphie und Fauna des Lias him nordwestlichen Deutschland. *Palaeontogr., Bd. 65.*

FISCHER, P. (1887), Manuel de Conchyliologie. *Paris.*

FREBOLD, H. (1957), The Jurassic Fernie Group in the Canadian Rocky Mountains and Foothills. *Geol. Surv. Canada, Mem. 287.*

FRECH, F. (1907), Die Leitfossilien der Werfener Schichten und Nachträge zur Fauna des Muscherkalkes, der Cassianer und Raibler Schichten sowie des Rhaet und des Dachsteinkalk (Haupt Dolomit). *Result. wissensch. Erforsch. Balatonsees, Pal. Bd. 1, Teil 1.*

FRENEIX, S. (1958), Contribution à l'Etude des Lamellibranches du Crétacé de Nouvelle-Calédonie. *Sci. de la Terre, Tom. 4, Nos. 3–4.*

GARDET, G. and GÉRARD, C, (1946), Contribution l'Etude paléontologique du Moyen-Atlas septentrional. Lias inférieur—Bathonien. *Notes et Mém. Serv. Maroc, No. 64.*

GOTTSCHE, C. (1878), Ueber jurassische Versteinerungen aus der argentinischen Cordillere. *Palaeontogr., Supple. 3, Lief. 2. Abt. 3.*

GREPPIN, E. (1898–1900), Description des Fossiles du Bajocien supérieur des Environs de Bâle. *Mém. Soc. pal. Suisse, Vols. 25–27.*

HABE, T. (1951–1953), Genera of Japanese Shells. Pelecypoda and Scaphopoda. (in Japanese)

HAYAMI, I. (1957 a), Liassic *Bakevellia* in Japan. *Japan. Jour. Geol. Geogr., Vol. 28, Nos. 1–3.*

——— (1957 b), Liassic *Gervillia* and *Isognomon* in Japan. *Ibid., loc. cit.*

——— (1957 c), On the Occurrence of *Cardinioides* from thi Liassic Kuruma Group in Central Japan. *Trans. Proc. Pal. Soc. Japan, N. S., No. 26.*

——— (1957 d), *Radulonectites*, a new Pectinid Genus, from the Liassic Kuruma Group in Central Japan. *Ibid., N. S., No. 27.*

——— (1957 e), Liassic *Chlamys*, "*Camptonectes*" and other Pectinids from the Kuruma Group in Central Japan. *Ibid., N. S., No. 28.*

——— (1958 a), Liassic *Volsella*, *Mytilus* and some other Dysodont Species in Japan. *Ibid., N. S., No. 29.*

——— (1958 b), A Review on the so-called Liassic "Cyrenoids" in Japan. *Japan. Jour. Geogr., Vol. 29, Nos. 1–3.*

——— (1958 c), Some Hettangian Pelecypods from the "*Trigonia*-sandstone" of the Shizukawa Group in Northeast Japan. *Ibid., loc. cit.*

——— (1958 d), Supplementary Descriptions of the Liassic Pelecypods in Japan. *Trans. Proc. Pal. Soc. Japan, N. S., No. 30.*

——— (1958 e), Taxonomic Notes on *Cardinia* with Description of a new Species from the Lias of Western Japan. *Jour. Fac. Sci. Univ. Tokyo, Sec. 2, Vol. 11, Pt. 2.*

——— (1959 a), Pelecypods of the Mizunuma Jurassic in Miyagi Prefecture with some stratigraphical Remarks. *Trans. Proc. Pal. Soc. Japan, N. S., No. 34.*

——— (1959 b), Bajocian Pelecypods of the Aratozaki Formation in Northeast Japan. *Japan. Jour. Geol. Geogr., Vol. 30,* in press.

——— (1959 c), Late Jurassic Isodont, Myacid and other Pelecypods from Makito Area in Central Japan. *Ibid., in press.*

HEALEY, M. (1908), The Fauna of the Napeng Beds or the Rhaetic Beds of Upper Burma. *Pal. Indica, N. S., Vol. 2, Mem., No. 4.*

ICHIKAWA, K. (1954), Late Triassic Pelecypods from the Kochigatani Group in the Sakuradani and Kito Areas, Tokushima Prefecture, Shikoku, Japan. Part 1. *Jour. Inst. Polytec. Osaka City Univ., Ser. G, Vol. 1.*

——— (1958), Zur Taxionomie und Phylogenie der Triadischen "Pteriidae" (Lamellibranch.) mit besondere Berücksichtigung der Gattungen *Claraia*, *Eumorphotis*, *Oxytoma* und *Monotis*. *Palaeontogr., Bd. 111, Abt. A.*

JAWORSKI, E. (1929), Eine Lias-Fauna aus Nordwest Mexico. *Mém. Soc. Pal. Suisse, Vol. 48.*

KIMURA, T. (1951), Some Pectinids and a Limid from the Jurassic Torinosu Group in Japan. *Jour. Fac. Sci. Univ. Tokyo, Sec. 2, Vol. 7, Pts. 6–10.*

——— (1956), Some Pelecypods from the Upper Jurassic Torinosu Group in Kochi Prefecture, Japan. *Jour. Earth Sci. Nagoya Univ., Vol. 4. No. 2.*

KIPARISOVA, L. D. (1952), New Lower Jurassic Fauna near Amur. *Trans. All Soviet Union Sci. Geol. Inst.* (in Russian)

——— (1954), Field illustrated Atlas of characteristic Flora and Fauna of Triassic Period in Maritime Province. (in Russian)

KOBAYASHI, T. (1926), Note on the Mesozoic Formation in Province of Nagato, Chugoku, Japan. *Jour. Geol. Soc. Tokyo, Vol. 33.* (in Japanese)

——— (1935 a), Contribution to the Mesozoic Faunas in Japan. *Ibid., Vol. 42.* (in Japanese)

——— (1935 b), the geological Structure of Southwestern Japan and its Mesozoic Palaeogeography. *Ibid., Vol. 42.* (in Japanese)

——— (1941), The Sakawa Orogenic Cycle and its Bearing on the Origin of the Japanese

Island. *Jour. Fac. Sci Imp. Univ. Tokyo, Sec. 2, Vol. 5, No. 7.*

——— and ICHIKAWA, K. (1949), *Tosapecten* gen. nov. and other Upper Triassic Pectinidae from the Sakawa Basin in Shikoku, Japan. *Japan. Jour. Geol. Geogr., Vol. 21, Nos. 1–4.*

——— and ——— (1950), On the Upper Triassic Kochigatani Series in Sakawa Basin and its Pelecypod Faunas. *Jour. Fac. Sci. Univ. Tokyo, Ser. 2, Vol. 7, Pts. 3–5.*

——— (1950), Chugoku District in Regional Geology of Japan. *Tokyo.* (in Japanese)

———, KONISHI, K., SATO, T., HAYAMI, I. and TOKUYAMA, A. (1957), On the Lower Jurassic Kuruma Group. *Jour. Geol. Soc. Japan, Vol. 63.* (in Japanese)

——— and MORI, K. (1954), Studies on the Jurassic Trigonians in Japan. Part 2. *Prosogyrotrigonia* and the Trigoniinae. *Japan. Jour. Geol. Geogr., Vol. 25, Nos. 3–4.*

——— and ——— (1955), Op. cit. Part 3. The Vaugoniinae from the Kitakami Mountains in North Japan. *Ibid., Vol. 26, Nos. 1–2.*

KONISHI, K. (1954), Yamaoku Formation (A Jurassic Deposit recently discovered in Okayama Prefecture). *Jour. Geol. Soc. Japan, Vol. 60.* (in Japanese)

KRUMBECK, L. (1905), Die Brachiopoden- und Mollusken-Fauna des Glandarienkalkes. *Beitr. Pal. u. Geol. Oesterr.-Ungarn Orients, Bd. 18.*

——— (1923), Zur Kenntnis des Juras der Insel Timor sowie des Aucellen-Horizontes von Seran und Buru. *Pal. Timor, Lief. 12.*

——— (1924), Die Brachiopoden, Lamellibranchiaten und Gastropoden der Trias von Timor. II. *Ibid., Lief. 13.*

KUHN, O. (1936), Die Fauna des Amaltheentons (Lias delta) in Franken. *Neues Jahrb. f. Min. usw., Beil.-bd. 75 B.*

LAUBE, G. C. (1867), Die Bivalven des Braunen Jura von Balin. *Wien.*

LYCETT, J. (1863), Supplementary Monograph on the Mollusca from the Stonesfield Slate, Great Oolite, Forest Marble, and Cornbrash. *Palaeontogr. Soc. London.*

MARWICK, J. (1935), Some new Genera of the Myalinidae and Pteriidae of New Zealand. *Trans. Roy. Soc. New Zealand, Vol. 65.*

MATSUMOTO, T. (1956), Yebisites, a new Jurassic Ammonite from Japan. *Trans. Proc. Pal. Soc. Japan, N. S., No. 23.*

MEEK, F. B. (1864), Check List of the Invertebrate Fossils of North America. Cretaceous and Jurassic. *Smithsonian Misc. Coll., No. 177.*

——— (1876), A Report on the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Country. *U. S. Geol. Surv. Terr.* (HAYDEN), *Rep. 9.*

MORET, L. (1958), Etude paléontologique de Gisements remarquables du Lias inférieur du Massif du Grand-Serre, près Grenoble. *Trav. Lab. Geol. Fac. Sci. Grenoble, Tom. 34.*

MORI, K. (1949), On the Jurassic Formations in the Hashiura District, Province of Rikuzen, Japan. *Japan. Jour. Geol. Geogr., Vol 21.*

MORRIS, J. and LYCETT, J. (1853), A Monograph of the Mollusca from the Great Oolite, chiefly from Minchinhampton and the Coast of Yorkshire. Part 2. Bivalves. *Palaeontogr. Soc. London.*

NEWELL, N. D. (1938), Late Paleozoic Pelecypods: Pectinacea. *Publ. Univ. Kansas, Vol. 10.*

NICOL, D. (1950), Recent Species of the lucinoid Pelecypod *Fimbria*. *Jour. Washington Acad. Sci., Vol. 40, No. 3.*

——— (1954), Nomenclatural Review of Genera and Subgenera of Cucullaeidae. *Jour. Pal., Vol. 28, No. 1.*

OYAMA, K. (1943), Conchologia Asiatica. Vol. 1, Pars 1. Familia Limidae. *Tokyo.* (in Japanese)

PHILIPPI, E. (1900 a), Beiträge zur Morphologie und Phylogenie der Lamellibranchier. II. Zur Stammesgeschichte der Pectiniden. *Zeit. deut. geol. Gesell., Bd. 52.*

——— (1900 b), Op. cit. III. *Lima* und ihre Untergattungen. *Ibid., Bd. 52.*

POMPECKJ, J. F. (1901), Ueber Aucellen und Aucellen-ähnlich Formen. *Neues Jahrb. f. Min. usw., Beil-Bd. 14.*

QUENSTEDT, F. A. (1852), Handbuch der Petrefactenkunde. *Tübingen.*

QUENSTEDT, W. (1930), Die Anpassung an die grabende Lebenweise in der Geschichte der Solenomyiden und Nuculaceen. *Geol. u. Pal. Abhandl., N. S., Bd. 18.*

ROLLIER, L. (1911–1918), Fossiles nouveaux ou peu connus des Terrains secondaires (Mésozoiques) du Jura et des contrées environnants. *Mém. Soc. pal. Suisse, Vols. 37–42.*

ROMAN, F. (1921) in RICHE and ROMAN, La Montagne de Crussol. Étude stratigraphique et paléontologique. *Trav. Labor. géol. Fac. Sci. Lyon, N. S., Fasc. 1.*

SATO, T. (1955), Les Ammonites recueillies dans le groupe de Kuruma, Nord du Japon central. *Trans. Proc. Pal. Soc. Japan, N. S., No. 20.*

——— (1956), Corrélation du Jurassique inférieur Japonais en basant sur les Ammonites Fossiles. *Jour. Geol. Soc. Japan, Vol. 62.* (in Japanese)

——— (1957), Biostratigraphie de la Série de Shizukawa (Jurassique inférieur) du Japon septentrional. *Jour. Fac. Sci. Univ. Tokyo, Sec. 2, Vol. 10, Pt. 3.*

SCHENCK, H. G. (1934), Classification of nuculid Pelecypods. *Mus. roy. d'Hist. nat. Belgique, Tom. 10, No. 20.*

SCHMIDTILL, E. (1926), Zur Stratigraphie und Faunenkunde des Doggersandsteins in nordlichen Frankenjura. *Palaeotogr., Bde. 67–68.*

STAESCHE, K. (1926), Die Pectiniden des schwäbischen Jura. *Geol. u. Pal. Abhandl., N. S., Bd. 15.*

STOLICZKA, F. (1870–1871), Cretaceous Fauna of Southern India, Vol. 3. Pelecypoda. *Pal. Indica, Ser. 6, Vol. 3.*

TAMURA, M. (1959 a), Trigoniidae, Ostreidae, Bakevelliidae, Pteriidae, Cardiidae and Astartidae from the Upper Jurassic Sakamoto Formation in Central Kyushu, Japan. *Trans. Proc. Pal. Soc. Japan, N, S., No. 33.*

——— (1959 b), Taxodonta and Isodonta from the Upper Jurassic Sakamoto Formation in Central Kyushu, Japan. *Ibid., N. S., No. 34.*

TATE, R. (1870). On the Palaeontology of the Junction Beds of the Lower and Middle Lias in Glaucestershire. *Quart. Jour. Geol. Soc. London, Vol. 26.*

THEVENIN, A. (1908), Paléontologie de Madagascar. V. Fossiles liasiques. *Ann. Paleont., Tom. 3, Fasc. 3.*

THIELE, J. (1934–1935), Handbuch der systematischen Weichtierkunde. Bd. 2. *Jena.*

TILMANN, N. (1917), Die Fauna des Unteren Lias in Nord- und Mittel-Peru. *Neues Jahrb. f. Min. usw., Beil.-Bd. 41.*

TONI, A. DE (1912), La Fauna liasica di Vedana. 2. Molluschi. *Mém. Soc. pal. Suisse, Vol. 38.*

TRECHMANN, C. T. (1918), The Trias of New Zealand. *Quart. Jour. Geol. Soc. London, Vol. 73.*

——— (1923), The Jurassic Rocks of New Zealand. *Ibid., Vol. 79.*

WAAGEN, L. (1901), Der Formenkreis des *Oxytoma inaequivalvis* SOWERBY. *Jahrb. d. k. k. geol. Reichsanst., Bd. 51.*

WARREN, P. S., (1932), A Lower Jurassic Fauna from Fernie, British Columbia. *Trans. Roy. Soc. Canada. Ser. 3, Vol. 25, Sec. 4.*

WHITFIELD, R. P. (1885), Brachiopoda and Lamellibranchiata of the Raritan Clays and Greensand Marls of New Jersey. *Mon. U. S. Geol. Surv., Vol. 9.*

WILCKENS, O. (1927), Contributions to the Palaeontology of the New Zealand Trias. *N. Z. Geol. Surv., Pal. Bull., No. 12.*

WILDBORNE, G. F. (1883), Notes on some Fossils, chiefly Mollusca, from the Inferior Oolite. *Quart. Jour. Geol. Soc. London, Vol. 39.*

WOODS, H. (1899–1913), A Monograph of the Cretaceous Lamellibranchiata of England. *Palaeontogr. Soc. London.*

YABE, H. and EGUCHI, M. (1933), *Anabacia cyclitoides*, sp. nov. from Japan with Remarks on the Genus *Anabacia. Japan. Jour. Geol. Geogr., Vol. 10.*

YEHARA, S. (1921), On some new Species of *Trigonia* from the Lias of Prov. Nagato and the Cretaceous of Prov. Awa. *Jour. Geol. Soc. Tokyo, Vol. 28.*

——— (1931), Trigoniae in Japan. *Iwanami Lecture Series. Geology and Palaeontology.*

(in Japanese)

YOKOYAMA, M. (1904 a), Jurassic Ammonites from Echizen and Nagato. *Jour. Coll. Imp. Univ. Tokyo, Vol. 19, Art. 20.*

——— (1904 b), On some Jurassic Fossils from Rikuzen. *Ibid., Vol. 18, Art. 6.*

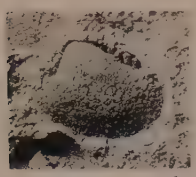
ZITTEL, K. VON (1881–1885), Handbuch der Palaeontologie. I. Abtheilung Palaeozoologie. Bd. 2. *München and Leipzig.*

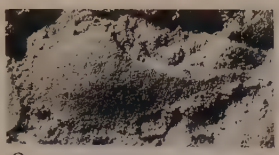
Plate V

Explanation of Plate V

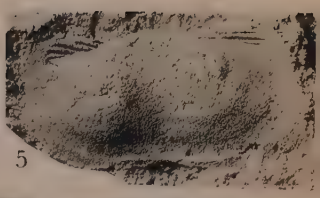
Nuculopsis (*Palaeonucula*) sp. indet. ..... p. 40
Fig. 1. Right internal mould (MM 3350), ×3, Loc. 5.
Nuculana (*Dacryomya*) *toriyamae* HAYAMI, n. sp, ... p. 41
Fig. 2. Left internal mould (MM 3353), paratype, ×2, Loc. 5.
Fig. 3. Clay cast of left external mould (MM 3352), holotype, ×2. Loc. 8. (TORIYAMA coll.)
Parallelodon infraliassicus HAYAMI, n. sp. ..... p. 42
Fig. 4. Left internal mould (MM 3356), paratype, ×1.5, Loc. 5.
Fig. 5. Fift internal mould (MM 3356), paratype, ×1.5, Loc. 5.
Fig. 6. Left internal mould (MM 3357), paratype, ×2, Loc. 5.
Parallelodon cf. *infraliassicus* HAYAMI ..... p. 43
Figs. 7a, b. Gypsum cast of right external mould and internal mould of the same specimen (MM 3359), ×1.5, Loc. 5.
Parallelodon (?) *subnavicellus* HAYAMI, n. sp. ..... p. 44
Figs. 8a, b. Right internal mould and clay cast of external mould of the same specimen (MM 3360), holotype, ×1, Loc. 5.
Grammatodon toyorensis HAYAMI, n. sp. ..... p. 45
Fig. 9. Left internal mould (MM 3361), holotype, ×2, Loc. 5.
Fig. 10. Left internal mould (MM 3362), paratype, ×2, Loc. 5.
Fig. 11. Left internal mould, exhibiting the dentition (MM 3364), ×2, Loc. 5.
Fig. 12. Clay cast of left external mould (MM 3363), paratype, ×2, Loc. 5.
Modiolus magatama HAYAMI, n. sp. ..... p. 46
Fig. 13. Left valve (MM 3366), holotype, ×2, Loc. 3.
Oxytoma cf. *cygnipes* (YOUNG and BIRD) ..... p. 48
Fig. 14. Left external mould (MM 3371) and internal mould of *Rimirhynchia* sp., ×1. Loc. 5.
Oxytoma kobayashii HAYAMI, n. sp. ..... p. 49
Fig. 15. Left internal mould (MM 3372), holotype, ×2, Loc. 9.
Fig. 16. Left valve (MM 3373), paratype, ×2. Loc. 9. (KOBAYASHI coll.)
Fig. 17. Right internal mould (MM 3374), paratype, ×2. Loc. 9.
Oxytoma inequivalve (SOWERBY) ..... p. 50
Fig. 18. Left valve (MM 3376), ×2, Loc. 4.
Fig. 19. Left valve (MM 3375), ×2, Loc. 9.
Meleagrinella japonica HAYAMI, n. sp. ..... p. 47
Fig. 20. Right internal mould (MM 3370), paratype, ×2, Loc. 8.
Fig. 21a, b. Left internal mould and clay cast of the same external mould (MM 3368), holotype, ×2, Loc. 8.
Fig. 22. Left internal mould (MM 3369), paratype, ×2, Loc. 3.
Chlamys textoria (GOLDFUSS) ..... p. 52
Figs. 23a–c. Internal and external moulds of right valve (MM 3379) and gypsum cast of the latter, ×1.2, Loc. 5.
Fig. 24. Internal mould of right valve (MM 3383), ×1.5, Loc. 5.
Fig. 25. Gypsum cast of right external mould (MM 3380), ×1.5, Loc. 5.
Figs. 26a, b. Right external mould (MM 3318) and its gypsum cast, ×1.5, Loc. 5.
Fig. 27. Gypsum cast of left external mould (MM 3382), ×1.2, Loc. 3.
"*Aequipecten*" sp. indet. ..... p. 57
Fig. 28. Gypsum cast of right (?) external mould (MM 3390), ×1, Loc. 5.

All specimens illustrated here are kept in the Geological Institute, University of Tokyo.


1

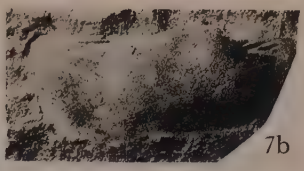

2

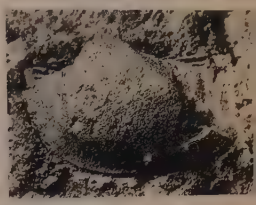
4

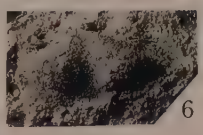

5

3

7a


7b

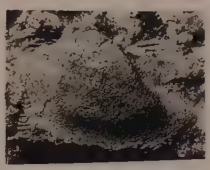

9


6

8a

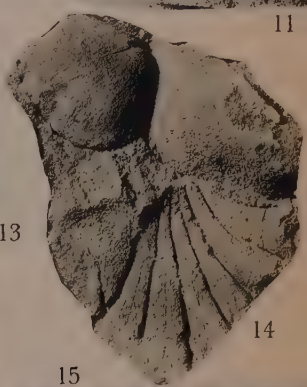
12

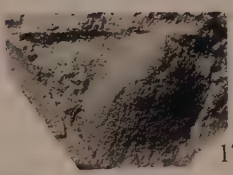
11

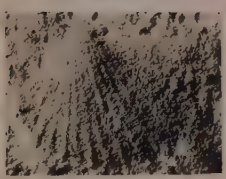

10

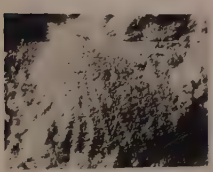
8b

13

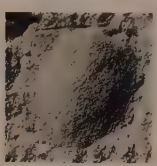

14

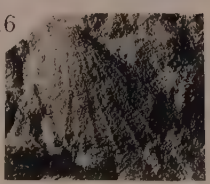

17

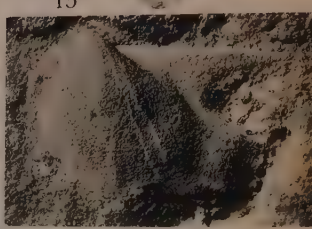

18

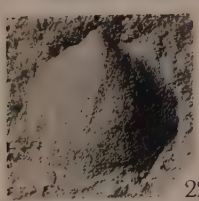

19

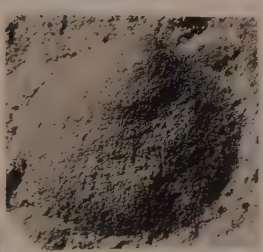
21b


20

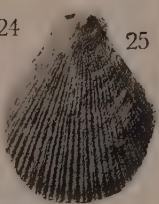

16


15


22


21a

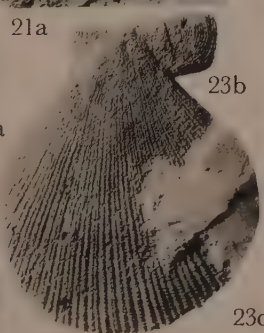
24


25

27

28

23a


23b

23c

26a

26b

I. Hayami

Lower Liassic Lamellibranch Fauna of the Higashinagano Formation in West Japan

Plate VI

Explanation of Plate VI

"Aequipecten" toyorensis HAYAMI, n. sp. ..... p. 55

Figs. 1a, b. Right internal mould and gypsum cast of the same external mould (MM 3384), holotype, ×2, Loc. 5.

Fig. 2. Clay cast of left external mould (MM 3385), paratype, ×2, Loc. 5.

Fig. 3. Right internal mould (MM 3386) paratype, ×2, Loc. 5.

Fig.4. Right internal mould (MM 3388), ×1, Loc. 6.

Fig. 5. Juvenile right internal mould (MM 3383), paratype, ×2, Loc. 5.

Entolium cf. *calvum* (GOLDFUSS) ..... p. 57

Figs. 6a, b. Left internal mould and clay cast of the same external mould (MM 3392), ×1.5, Loc. 5.

Fig. 7. Right internal mould (MM3391), ×1.2, Loc. 5.

Fig. 8. Fragmental right internal mould (MM 3393), ×1.2, Loc. 3.

Fig. 9. Left internal mould (MM 3393), ×1.2, Loc. 3.

Entolium sp. indet. ..... p. 60

Fig. 10. Right internal mould (MM 3398), ×1.5, Loc. 9. (KOBAYASHI coll.)

Entolium cf. *lunare* (ROEMER) ..... p. 59

Fig. 11. Left internal mould (MM 3396), ×1, Loc. 3.

Entolium (?) sp. indet. ..... p. 60

Fig. 12. Left internal mould (MM 3399), ×1.5, Loc. 5.

Fig. 13. Clay cast of left external mould (MM 3400), ×1.5, Loc. 5.

Plicatula subcircularis HAYAMI, n. sp. ..... p. 60

Fig. 14. Left internal mould (MM 3401), holotype, ×1, Loc. 5.

Fig. 15. Clay cast of left external mould (MM 3402), paratype, ×1.2, Loc. 5.

Fig. 16. Right internal mould (MM 3403), ×1, Loc. 5.

Plicatula praenipponica HAYAMI, n. sp. ..... p. 61

Fig. 17. Left internal mould (MM 3407), paratype, ×1, Loc. 5.

Fig. 18. Clay cast of left external mould (MM 3409), ×1, Loc. 5.

Figs. 19a, b. Left internal mould and gypsum cast of the same external mould (MM 3406), holotype, ×1.2, Loc. 5.

"Lima" sp. indet. ..... p. 62

Fig. 20. Left valve (MM 3410), ×2, Loc. 9. (KOBAYASHI coll.)

Plagiostoma kobayashii HAYAMI, n. sp. ..... p. 63

Fig. 21a. Gypsum cast of right external mould (MM 3411), holotype, ×1, Loc. 5.

Fig. 21b. Postero-dorsal part of the same specimen, ×3.

Fig. 22. Gypsum cast of right external mould (MM 3413), ×1, Loc. 5.

Fig. 23. Right internal mould (MM 3412), paratype, ×1, Loc. 5.

Plagiostoma matsumotoi HAYAMI, n. sp. ..... p. 64

Fig. 24. Right internal mould (MM 3417), paratype, ×1, Loc. 5.

Fig. 25. Left intarnal mould (MM 3414), holotype, ×1, Loc. 3.

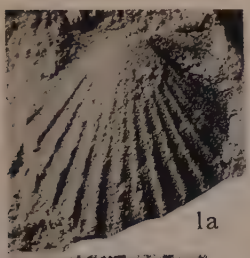
Plagiostoma sp. indet. ..... p. 65

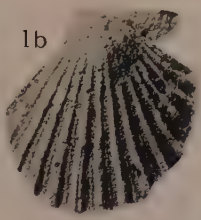
Fig. 26. Right valve (MM 3420), ×1.5, Loc. 9. (KOBAYASHI coll.)

Ctenostreon sp. indet. ..... p. 68

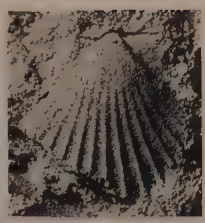
Fig. 27. Clay cast of right external mould (MM 3427), ×1, Loc. 5.

All specimens illustrated here are kept in the Geological Institute, University of Tokyo.


1a


1b

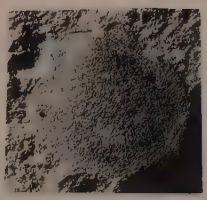
2


3

4

7

8

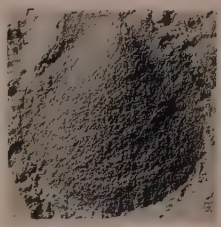

12

10

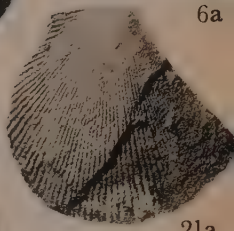
6a

6b

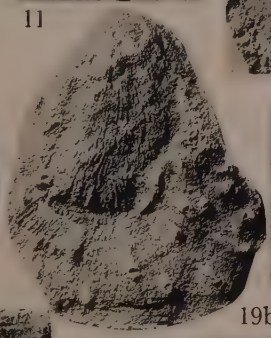
11


9

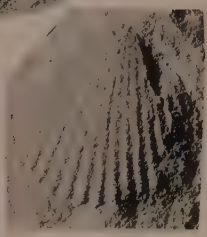
13

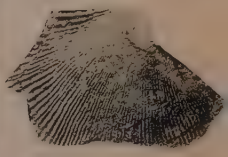

21a

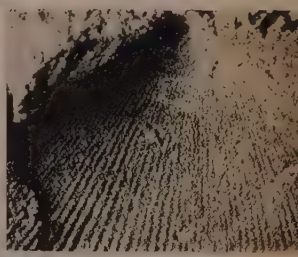
18


19b

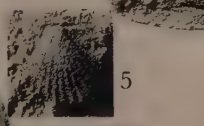
14


20


22


21b

17


5

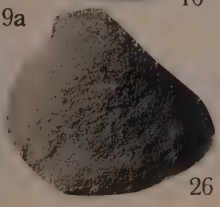
15

25

27

19a

16


26

24

23

Plate VII

Explanation of Plate VII

Plagiostoma matsumotoi HAYAMI, n. sp. ..... p. 64

Fig. 1. Right internal mould (MM 3416), paratype, ×1, Loc. 5.

Fig. 2. Gypsum cast of left external mould (MM 3415), paratype, ×1, Loc. 5.

Fig. 3. Postero-dorsal part of left external mould (MM 3418), ×3, Loc. 5.

Antiquilima nagatoensis HAYAMI, n. sp. ..... p. 66

Figs. 4a, b. Left internal mould and gypsum cast of the same external mould (MM 3421), holotype, ×1, Loc. 5.

Fig. 4c. Postero-ventral part of the same specimen, ×3, Loc. 5.

Ctenostreon japonicum HAYAMI, n. sp. ..... p. 67

Figs. 5a, b. Right internal mould and gypsum cast of the same external mould (MM 3424), holotype, ×1, Loc. 5.

Fig. 6. Gypsum cast of right external mould (MM 3425), paratype, ×1, Loc. 5.

Liostrea toyorensis HAYAMI, n. sp. ..... p. 68

Fig. 7. Left internal mould (MM 3428), holotype, ×1, Loc. 5.

Fig. 8. Right internal mould (MM 3430), paratype, ×1, Loc. 5.

Lopha sazanami HAYAMI, n. sp. ..... p. 69

Fig. 9. Right internal mould (MM 3431), paratype, ×1, Loc. 5.

Fig. 10. Right external mould (MM 3433), paratype, ×1, Loc. 5.

Fig. 11. Gypsum cast of right external mould (MM 3432), holotype, ×1, Loc. 5.

Prosogyrotrigonia inouyei (YEHARA) ..... p. 70

Fig. 12. Clay cast of left external mould (MM 3437), ×1, Loc. 3.

Fig. 13. Left internal mould (MM 3436), ×1.5, Loc. 5.

Fig. 14. Clay cast of left external mould (MM 3438), ×1.5, Loc. 3.

Praeconia cf. *tetragona* (TERQUEM) ..... p. 71

Fig. 15. Left internal mould (MM 3444), ×1.5, Loc. 5.

Fig. 16. Right internal mould (MM 3445), ×1.5, Loc. 5.

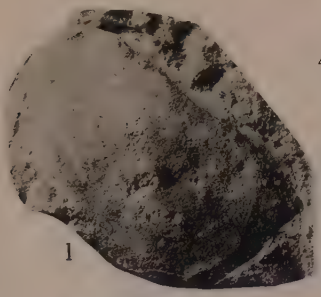
Astarte a sp. indet. ..... p. 73

Fig. 17. Right internal mould (MM 3447), ×3, Loc. 5.

Oxytoma inequivalve (SOWERBY) ..... p. 50

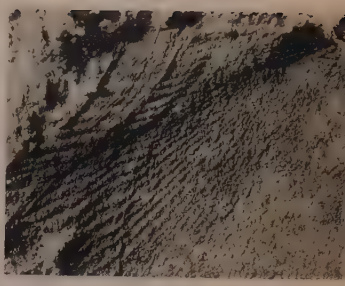
Fig. 18. Right valve (MM 3376), ×2, Loc. 9.

All specimens illustrated here are kept in the Geological Institute, University of Tokyo.

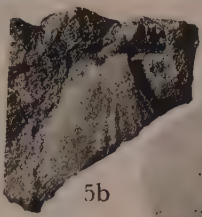

1

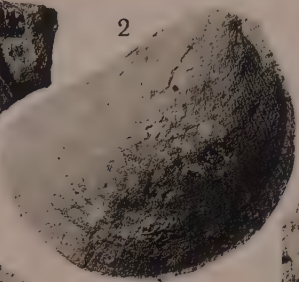
4a

4b

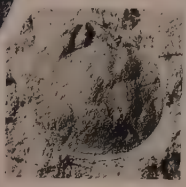

3

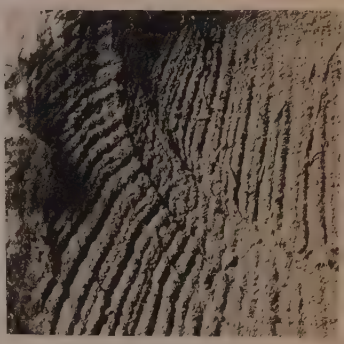
5a

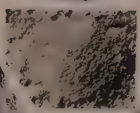

5b


2

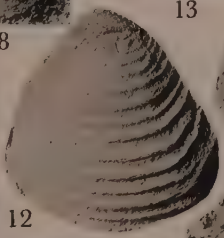
6


13

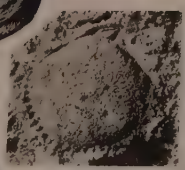

4c

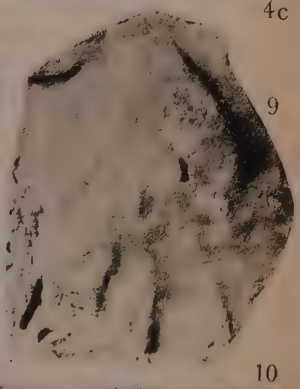

18

7

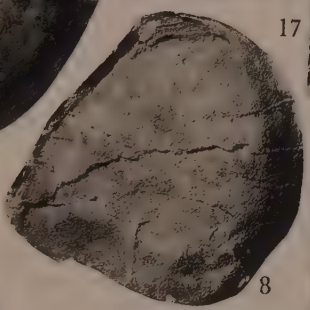

12

14


17


9

10


8

11

15

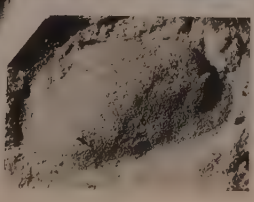

16

Plate VIII

Explanation of Plate VIII

Cardinia orientalis HAYAMI, n. sp. ..... p. 70

Fig. 1. Right internal mould (MM 3439), holotype, ×1, Loc. 3.

Praeconia cf. *tetragona* (TERQUEM) ..... p. 71

Fig. 2. Clay cast of left external mould (MM 3444), the same specimen as on Pl. III, fig. 15, ×2, Loc. 5.

Fig. 3. Left internal mould with impression of exterior of *Sphaeriola nipponica* (MM 3443), ×1, Loc. 5.

Fig. 4. Gypsum cast of fragmental mould of left valve (MM 3442), ×1, Loc. 5.

Astarte b sp. indet. ..... p. 73

Figs. 5a, b. Left internal mould and clay cast of the same external mould (MM 3448), ×3, Loc. 5.

Lucina (s. l.) *hasei* HAYAMI, n. sp. ..... p. 76

Fig. 6. Clay cast of right external mould (MM 3457), paratype, ×2. Loc. 5.

Figs. 7a, b. Left internal mould and clay cast of the same external mould (MM 3455), holotype, ×3, Loc. 1.

Fig. 8. Clay cast of right external mould (MM 3456), paratype, ×2, Loc. 5.

Fimbria sp. indet. ..... p. 74

Fig. 9. Clay cast of external mould (MM 3449), ×2, Loc. 5.

Sphaeriola nipponica HAYAMI, n. sp. ..... p. 74

Fig. 10. Gypsum cast of right internal mould (MM 3451), paratype, ×1, Loc. 5.

Fig. 11a, b. Left external mould and clay cast of the same specimen (MM 3452), paratype, ×1.2, Loc. 5.

Fig. 12a, b. Right internal mould and clay cast of the same specimen (MM 3450), holotype, ×1.2, Loc. 5.

Fig. 13. Clay cast of left external mould (MM 3453), paratype, ×1.2, Loc. 5

Cardium (s. l.) *naganoense* HAYAMI, n. sp. ..... p. 77

Figs. 14a, b. Right internal mould and clay cast of the same external mould (MM 3461), holotype, ×1.2, Loc. 5.

Fig. 15. Left internal mould (MM 3462), paratype, ×1.2, Loc. 5.

Protocardia onoi HAYAMI, n. sp. ..... p. 77

Fig. 16. Left internal mould (MM 3464), paratype, ×2, Loc. 5.

Fig. 17. Clay cast of left external mould (MM 3463), holotype, ×2, Loc. 5.

Fig. 18. Clay cast of left external mould (MM 3465), paratype, ×1.5, Loc. 5.

Pleuromya sp. indet. ..... p. 78

Fig. 19. Left internal mould (MM 3467), ×2, Loc. 3.

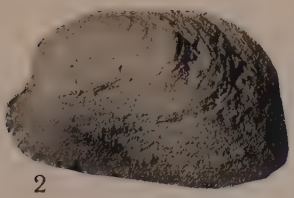
Genus and species indet. b ..... p. 79

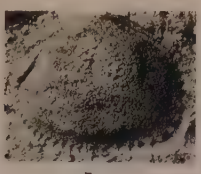
Fig. 20. Right internal mould (MM 3468), ×1, Loc. 5.

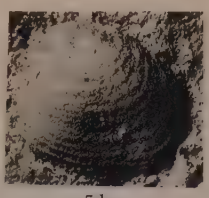
Genus and species indet. a ..... p. 78

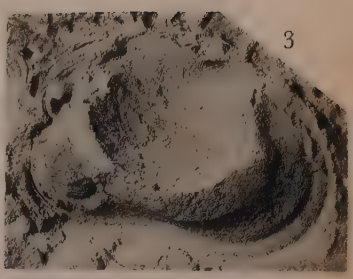
Fig. 21. Right internal mould (MM 3469), ×1, Loc. 5.

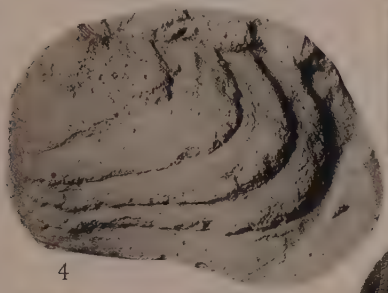
All specimens illustrated here are kept in the Geological Institute, University of Tokyo.

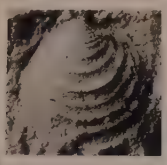

2

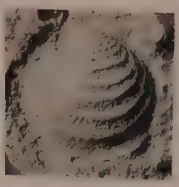

5a

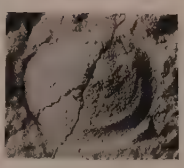

5b

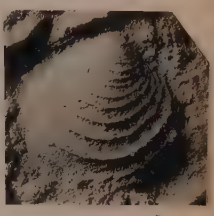

3

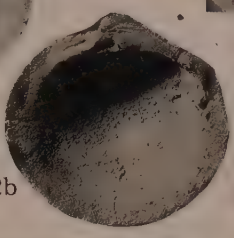

4

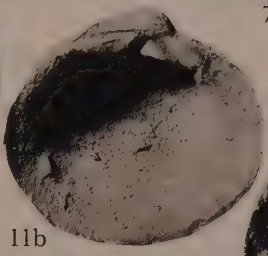

6


7a


7b

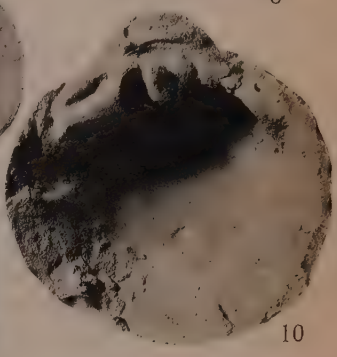

8

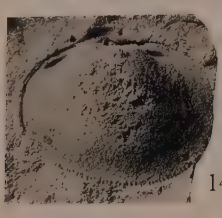

12b

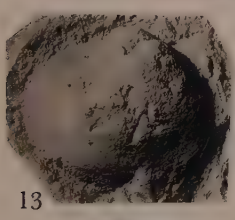

11b

12a

9


10


14a

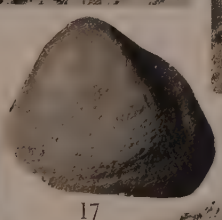

13

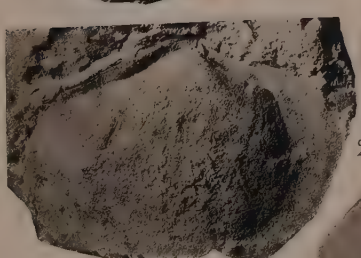
15

14b

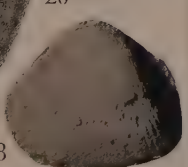
16

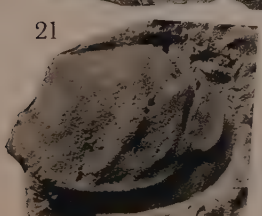
11a

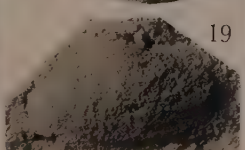

17


20

1


18


21


19

HORNBLENDES OF BASIC METAMORPHIC ROCKS

Fumiko SHIDÔ and Akiho MIYASHIRO

Abstract

Five hornblendes from basic metamorphic rocks of the central Abukuma Plateau in Japan and six hornblendes from Dalradian epidiorites of the Grampian Highlands in Scotland were separated and analyzed. The relation between their compositions and the physical and chemical conditions during the metamorphisms concerned are discussed in some detail. The results generally confirm our earlier conclusions.

The progressive compositional variations of plagioclase and epidote in Dalradian epidiorites are examined. Analyses of a chlorite and pyralspite garnet from Dalradian epidiorites are given, and their paragenetic relations are discussed.

I. Introduction

Recently we studied the regional metamorphic rocks of the central Abukuma Plateau in Japan (SHIDÔ, 1958; MIYASHIRO, 1958). The mineralogical variations with increasing grade of metamorphism were described in detail. Similarities and differences between this regional metamorphism and that of the Grampian Highlands of Scotland were discussed. The data on the Grampian Highlands were taken from the literature, especially from WISEMAN (1934) and SNELLING (1957).

After our papers were published, we still felt it desirable to obtain further mineralogical data on the basic metamorphic rocks, not only of the central Abukuma Plateau but also of the Grampian Highlands for the purpose of complementing our discussion. Then, five new analyses were made on metamorphic hornblendes of the central Abukuma Plateau. We had a set of specimens of basic metamorphic rocks, usually called *epidiorites* by British geologists, from the Grampian Highlands. They were kindly given to us by Dr. S.O. AGRELL of the University of Cambridge in the autumn of 1957. We studied hornblendes and other minerals in these epidiorite specimens.

The results of these studies will be given in this paper.

We are greatly indebted to Dr. S.O. AGRELL for the epidiorite specimens. Our sincere thanks are due to Prof. I. IWASAKI, Dr. T. KATSURA and Mr. H. HARAMURA of the Tokyo Institute of Technology for the chemical analyses used in this paper.

II. Calciferous Amphiboles of the Central Abukuma Plateau

1. Summary of our Earlier Results on the Calciferous Amphiboles of the Central Abukuma Plateau

In the central Abukuma Plateau, SHIDÔ (1958) and MIYASHIRO (1958) adopted

Recevied June 3, 1959.

calciferous amphiboles in basic metamorphic rocks as index minerals for zonal mapping of the metamorphic terrian. Thus, three zones, A, B, and C in the order of increasing grade of metamorphism, were distinguished. Zone A is characterized by actinolite, zone B is characterized by blue-green common hornblende (i. e. hornblende with Z=bluish green or greenish blue), and zone C is characterized by common hornblende without bluish tinge (Z=green, greenish brown, and brown). These three kinds of calciferous amphiboles have different fields in the 2V-γ diagram (Fig. 1).

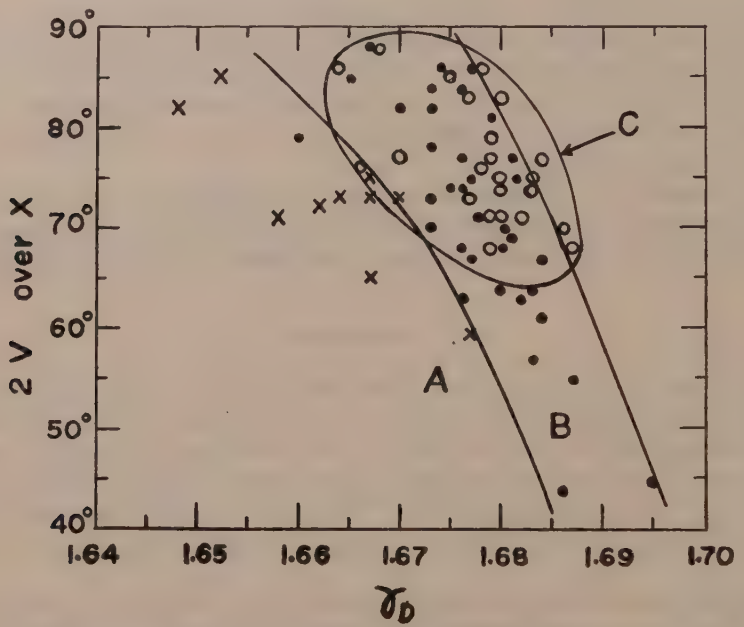


Fig. 1. Optic angle and index γ of calciferous amphiboles in regional-metamorphic basic rocks of the central Abukuma Plateau. (This figure was prepared from the data underlying Miyashiro, 1958, and Shidô, 1958, together with new ones.)

Cross: actinolite from zone A.

Solid circle: blue-green hornblende from zone B.

Open circle: hornblende from zone C.

A, B and C in this figure represent the fields of amphiboles of zones A, B and C respectively. The zone-C hornblende that falls on the lower left side of the boundary between fields A and B represents No. 13 in Table 2.

Especially SHIDÔ (1958) made a detailed investigation on the compositional variation of calciferous amphiboles. Her paper gives ten chemical analyses of hornblendes from zones B and C, which are quoted in Tables 1 and 1a. Her conclusions will be summarized below:

(1) In the transitional grade between zones A and B, actinolite coexists with blue-green hornblende. The two amphiboles are sometimes in zonal arrangement (with a hornblende rim) and sometimes in parallel growth. When they are in mutual contact the boundary between them is always sharp. The compositional change between the actinolite and hornblende appears abrupt and discontinuous. Even the hornblende in the transitional grade has high Al^{IV} and Al^{VI} contents similarly as that in the higher grades. Thus, probably there is

Table 1. Chemical analyses of hornblendes from regionally metamorphosed basic rocks of the central Abukuma Plateau (SHIDÔ, 1958, Table 7)

	Zone C					Zone B				
	1	2	3	4	5	6	7	8	9	10
SiO_2	42.94	45.62	42.44	43.20	44.36	40.96	44.03	42.62	44.07	44.60
Al_2O_3	12.56	8.87	12.50	12.44	11.69	11.70	12.33	12.75	12.37	12.12
TiO_2	1.89	1.13	3.09	1.65	1.26	0.99	0.46	0.53	1.70	0.87
Fe_2O_3	1.83	2.85	2.07	3.21	1.29	5.32	3.33	6.01	0.18	2.72
FeO	13.42	16.09	12.38	10.10	16.63	13.30	13.27	14.00	10.23	16.21
MgO	10.84	10.13	11.43	13.27	9.71	11.06	12.17	8.52	14.20	8.89
MnO	0.29	0.32	0.30	0.21	0.43	0.69	0.41	0.33	0.18	0.37
CaO	11.31	11.42	10.90	11.36	11.82	12.72	10.82	11.65	12.42	10.78
Na_2O	1.99	1.27	2.21	2.72	0.79	1.06	1.59	1.28	1.00	0.98
K_2O	0.35	0.33	0.14	0.40	0.50	1.27	0.23	0.55	0.30	0.50
$H_2O(+)$	2.23	1.92	1.94	1.38	1.67	1.50	1.32	1.91	2.85	2.03
$H_2O(-)$	0.22	0.16	0.15	0.07	0.12	0.06	0.07	0.12	0.03	0.11
F	n. d.	n. d.	n. d.	n. d.	n.d.	0.13	n. d.	n. d.	n. d.	n. d.
P_2O_5	n. d.	n. d.	0.23	0.07	0.12	n.d.	0.07	n. d.	n. d.	0.21
Tota	99.87	100.11	99.78	100.08	100.39	100.76	100.10	100.27	99.53	100.39
α_D	1.659	1.662	1.653	1.654	1.650	1.663	1.657	1.665	1.656	1.660
γ_D	1.688	1.687	1.676	1.680	1.679	1.686	1.675	1.683	1.673	1.682
2V(−)	76°	68.5°	84°	83°	79°	44°	74°	65.5°	82°	63°
c/\Z	26°	23°	15°	19°	15°	25°	18°	20°	19°	15°
X	p. brown	p. yellow	p. yellow	v. p. yellow	v. p. yellow	yellow	v. p. yellow	p. yellow	v. p. yellow	colorless
Y	brown	greenish brown	sepia-brown	green-yellowish brown	yellow-greenish brown	d. yellowish green	l. green	green	p. yellow-brownish green	l. green
Z	brown	greenish brown	sepia-brown	greenish brown	yellow brownish green	bluish green	l. bluish green	greenish blue	bluish green	l. bluish green

Note: In No. 2, β=1.674; In No. 1, sp. gr.=3.164. p=pale, v. p.=very pale, l=light, d=deep.

Table 1a. Host-rocks of the analyzed hornblendes of Table 1.

No. 1: Clinopyroxene-bearing amphibolite from Yamatama.
No. 2: Clinopyroxene-bearing amphibolite from Yôzikata.
No. 3: Amphibolite from Yokogawa.
No. 4: Biotite-amphibolite from Kamata.
No. 5: Clinopyroxene-amphibolite from between Otake and Tinokubo.
No. 6: Clinopyroxene-rich lens in amphibolite from Domeki.
No. 7: Biotite-bearing hornblende-schist from Yôzikata.
No. 8: Biotite-hornblende-schist from Yôzikata.
No. 9: Epidote-hornblende-plagioclase-schist from Kamiyama.
No.10: Biotite-bearing hornblende-schist from Odaira.

Note: For more detailed information, see SHIDÔ (1958, pp. 173–175).
The atomic ratios and molecular compositions are given in Tables 8 and 12 of SHIDÔ (1958).

a miscibility gap between actinolite and hornblende under the physical conditions of the transitional grade.

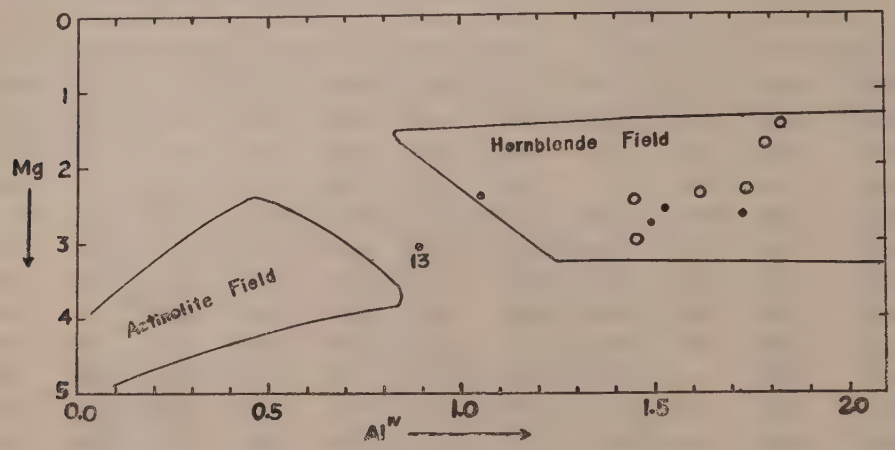


Fig. 2. Composition fields of actinolites and of common hornblendes from metamorphic rocks of basic and intermediate compositions of the world. The abscissa and ordinate respresent the amount of Al^{IV} and Mg, respectively, calculated on the anhydrous basis of O=23.
Solid circle: new analysis of hornblende from the central Abukuma Plateau.
Open circle: new analysis of hornblende from Highland epidiorite.
Note that hornblende No. 13 from Abukuma falls between the fields of actinolites and comm hornblendes.

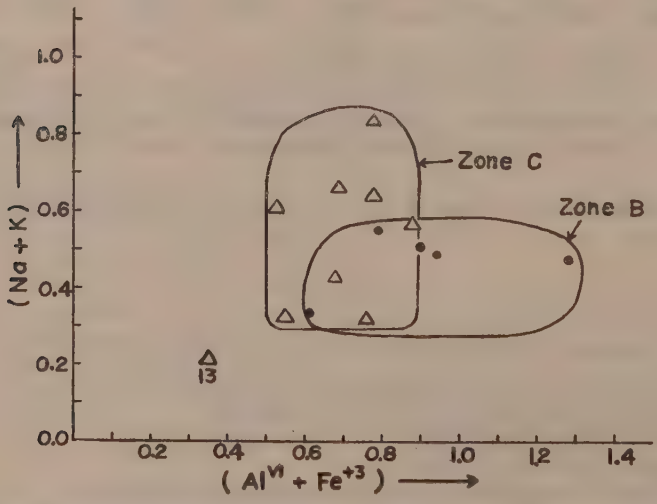


Fig. 3. Composition relation of hornblendes of zones B and C in the central Abukuma Pleteau. The coordinates show atomic ratios on the anhydrous basis of O=23. The point shifts toward the right with increasing content of tschermakite molecule, whereas it shifts upwards with increasing contents of edenite and sodatremolite molecules.
Solid circle: hornblende from zone B.
Triangle: hornblende from zone C.
Note that hornblende No. 13 is anomalous.

The existing chemical analyses of actinolites and those of common hornblendes, both from basic (and intermediate) metamorphic rocks of the world, fall in different fields, as shown in Fig. 2. This fact would correspond to the probable existence of a miscibility gap between the two minerals.

(2) HARRY (1950) claimed that the Al^{IV} content of calciferous amphiboles increases regularly with metamorphic grade. Such an increase, however, was not noticed in this region. Throughout zones B and C, hornblendes have large contents of tschermakite molecule, i.e. Al^{IV} and Al^{VI}. The tschermakite molecule tends to be expelled in zone C with resultant formation of cummingtonite and calcic plagioclase (Fig. 3). This breakdown reaction of the tschermakite molecule requires a supply of silica from outside, and hence the decrease of tschermakite molecule in zone C is more pronounced in quartz-bearing rocks.

(3) The alkali content of hornblende varies with the composition of its host-rock as well as with the physical conditions concerned. The hornblende associated with more sodic plagioclase tends to have a higher alkali content than that associated with more calcic one, and the hornblende in quartz-free rocks would tend to have a higher alkali content than that in quatz-bearing rocks. The maximum possible content of alkalies in hornblende in a particular metamorphic grade increases with increasing grade of metamorphism (Fig. 4).

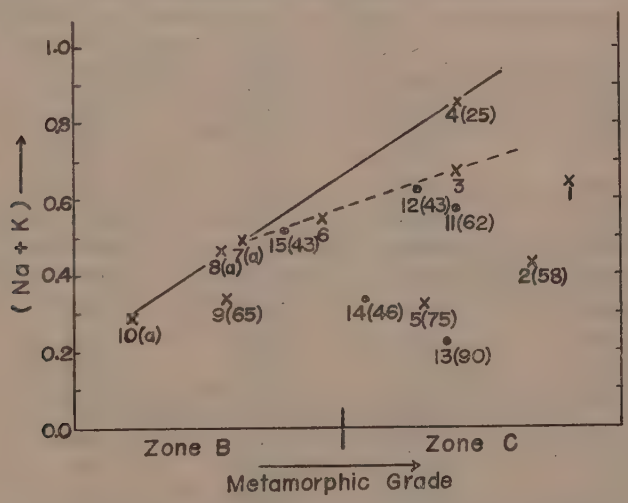


Fig. 4. Relation between the (Na+K) contents of common hornblendes on the anhydrous basis of O=23 and the metamorphic grade of the host-rock in the central Abukuma Plateau.
The figures within parentheses represent the An % of the associated plagioclase. Then, for example, 4 (25) means that the hornblende is No. 4 in Table 1, and the associated plagioclase has composition of 25 % An. Letter a in parentheses represents that the associated plagioclase is andesine. Nos. 2 and 14 are associated with quartz, while Nos. 4, 5, 9, 11, 12, 13, and 15 are not associated with quartz.

2. New Chemical Analyses of Hornblendes

Five more hornblendes were analyzed from regional-metamorphic basic rocks of the central Abukuma Plateau. The results are shown in Table 2. The atomic ratios and molecular compositions calculated from them are shown in Tables

3 and 4. These new analyses have generally confirmed SHIDÔ's (1958) results summarized in the preceding section.

Hornblende No. 13 from zone C is unusually low in Al_2O_3 and especially low in Al^{IV}. As shown in Fig. 2, this hornblende falls in the gap between the field of actinolites and that of common hornblendes. It suggests that the miscibility gap between actinolite and hornblende, which exists in a lower grade, vanishes in so high a grade or that the gap shifts toward lower Al^{IV} compositions with increasing grade. The optic properties of this hornblende are unusual, as is indicated by its unusual location in the $2V$–γ diagram (Fig. 1). It suggests that hornblendes with such compositions are rare.

The progressive increase of the alkali content with increasing metamorphic grade holds good. Hornblende No. 13 is associated with unusually calcic plagioclase ($Ab_{10}An_{90}$), and probably hence it is unusually poor in alkalies. Hornblende No. 4 is associated with a plagioclase rather exceptionally sodic for this grade ($Ab_{75}An_{25}$), and moreover it is not associated with quatz. Then, it is rather

Table 2. New chemical analyses of hornblendes from regionally metamorphosed basic rocks of the central Abukuma Plateau.

	Zone C				Zone B
	11	12	13	14	15
SiO_2	44.12	43.48	48.83	46.88	42.74
Al_2O_3	11.06	10.33	6.58	8.54	13.29
TiO_2	0.73	1.16	0.78	0.84	0.78
Fe_2O_3	4.14	2.18	1.02	0.99	3.05
FeO	12.46	15.19	12.76	17.18	12.74
MgO	12.56	11.66	13.98	10.89	12.07
MnO	0.19	0.24	0.34	0.28	0.44
CaO	10.57	11.95	12.88	11.22	11.62
Na_2O	1.89	1.99	0.58	1.03	1.56
K_2O	0.18	0.24	0.28	0.17	0.36
$H_2O(+)$	1.97	1.90	1.82	1.87	1.77
$H_2O(-)$	0.13	0.00	0.12	0.12	0.05
P_2O_5	tr.	0.11	0.22	0.09	0.04
Total	100.00	100.43	100.19	100.10	100.51
α_D	1.659	1.657	1.642	1.652	1.656
γ_D	1.675	1.683	1.666	1.679	1.676
$2V_X$	85°	74°	76°	77°	77°
$c \wedge Z$	16°	24°	23°	24°	22°
X	v. p. yellow	p. brownish yellow	p. yellow	p. yellow	p. yellow
Y	brownish yellow	greenish brown	brownish yellow	greenish brown	yellow-brownish green
Z	brownish yellow	greenish brown	greenish yellow	greenish brown	greenish blue
Absorp.	Y>Z>X	Y=Z>X	Y>Z>X	Y=Z>X	Y=Z>X
Disp.	r>v	r>v	r>v	r>v	r>v

All the analyses made by H. HARAMURA.
Note: v.=very, p.=pale.

Host rocks of the hornblendes of Table 2:

No. 11: Amphibolite from Matukawa, Hurudono-mura, Higasi-sirakawa-gun, Hukusima Prefecture (Specimen No. AM491110–12).

This rock probably belongs to the middle-grade part of zone C. It is composed of hornblende and plagioclase (An 62～50) with small amounts of opaque mineral and apatite. The plagioclase shows zonal structure with a more calcic rim than the core.

No. 12: Clinopyroxene-bearing amphibolite at the locality 2 kilometers east of Hatatate-toge, Sekimoto-mura, Taga-gun, Ibaragi Prefecture (Specimen No. FS561130–15).

This rock probably belongs to the middle-grade part of zone C. It consists of thin alternation in microscopic scale of hornblende-rich layers and clinopyroxene-rich ones, the former being composed mainly of hornblende and plagioclase (An 43～39) with small amounts of clinopyroxene and opaque mineral, and the latter mainly of clinopyroxene (Di 44 Hd 56) and plagioclase (An 43～39) with small amounts of hornblende and opaque mineral.

No. 13: Hornblende-schist from Sekimoto-mura, Taga-gun, Ibaragi Prefecture (Specimen No. FS 56051205).

This rock was found as a boulder and probably belongs to the middle-grade part of zone C. It is mainly composed of hornblende and plagioclase (An 90) with a small amount of opaque mineral.

No. 14: Amphibolite from 1 kilometer east of Hatatate-toge, Sekimoto-mura, Taga-gun, Ibaragi Prefecture (Specimen No. FS 561130–17).

This rock probably belongs to the lower- or middle-grade part of zone C. It is composed mainly of hornblende, plagioclase (An 46～40), and quartz with a small amount of opaque mineral. The plagioclase shows distinct two-layer zoning with a more calcic rim than the core.

No. 15: Biotite-bearing amphibolite from the vicinity of Kaiya, Tabito-mura, Iwaki-gun, Hukusima Prefecture (Specimen No. AM 550910–10).

This rock probably belongs to the higher-grade part of zone B. It is composed mainly of hornblende and plagioclase (the core=An 43～37, the rim=more calcic) with small amounts of biotite (β=1.615; Z=dark orange) and opaque mineral.

Table 3. Atomic ratios calculated from the hornblende analyses of Table 2 on the anhydrous basis of O=23.

	Zone C				Zone B
	11	12	13	14	15
Si	6.501	6.469	7.110	6.948	6.270
Al^{IV}	1.499	1.531	0.890	1.052	1.730
Al^{VI}	0.421	0.280	0.240	0.440	0.568
Ti	0.065	0.130	0.086	0.093	0.086
Fe^{+3}	0.458	0.245	0.112	0.110	0.337
Fe^{+2}	1.534	1.889	1.553	2.128	1.562
Mg	2.757	2.585	3.032	2.404	2.638
Mn	0.024	0.030	0.042	0.036	0.055
Ca	1.668	1.904	2.009	1.781	1.826
Na	0.540	0.574	0.164	0.296	0.444
K	0.034	0.046	0.052	0.032	0.067
(Na+K)	0.574	0.610	0.216	0.328	0.511

exceptionally rich in alkalies. Therefore, we may conclude that the upper limit of the alkali content in hornblende from basic metamorphic rocks with plagioclase of ordinary compositions in the central Abukuma Plateau is as is indicated by a dotted line in Fig. 4.

The tendency of decrease in tschermakite molecule in passage from zone B to C has become clearer by the new analyses, as shown in Fig. 3. The effect of free silica on the breakdown reaction of tschermakite molecule has not been demonstrated.

Table 4. Molecular compositions of the analyzed hornblendes of Table 2, calculated after the method of SHIDÔ (1958).

	Zone C				Zone B
	11	12	13	14	15
Tiam	0.132	0.260	0.172	0.186	0.172
Cum	1.036	0.636	0.260	0.844	0.984
Ts′	1.406	0.840	0.563	0.880	1.448
Ce′	——	0.128	0.148	——	0.144
St′	0.292	——	——	0.032	
Gl	——	——	——	——	——
Ed′	0.428	0.620	0.216	0.312	0.511
Tr	4.744	5.516	6.640	5.744	4.740

Note: The total of all the molecules in each hornblende is taken to be very close to 8.

III. Calciferous Amphiboles of the Grampian Highlands

1. Localities, Metamorphic Grades and Descriptions of the Epidiorite Specimens

The epidiorite specimens, which were sent by Dr. AGRELL, are shown in Table 5. They are classified on the basis of the calciferous amphiboles they contain, because the calciferous amphiboles may be regarded as an indicator of metamorphic grades.

Table 5. Epidiorite specimens from the Dalradian in the Grampian Highlands of Scotland

Group I: Epidiorites without amphibole or with actinolite.

No. 30216: Epidote-chlorite-albite-quartz-schist from Port Sornachan, Loch Awe, Argyllshire. Albite=3%An; chlorite, β=1.627.

No. 48891: Actinolite-chlorite-epidote-albite-rock from Crinan Canal, Argyllshire. Albite=5%An; actinolite, γ=1.652, 2V=72°.

No. 19951: Actinolite-chlorite-epidote-albite-quartz-rock from Dunderacoe Point, Loch Fyne, Argyllshire. Albite=5% An; actinolite, γ=1.653, 2V=75°; chlorite, β=1.620.

No. 48893: Actinolite-biotite-chlorite-epidote-albite-schist from Creag Bhreac, Kilmartin, Argyllshire. Albite=3% An; actinolite, γ=1.648, 2V=76°. A minute amount of blue-green hornblende is present.

No. 6905: Actinolite-chlorite-epidote-albite-rock (blastophitic) from Branfield Bay, south of Ardrishaig, Loch Fyne, Argyllshire. Albite=5% An; actinolite, γ=1.647, 2V=79°–75°.

Group II: Epidiorites with blue-green hornblende.

No. 48892: Blue-green hornblende-chlorite-epidote-albite-quartz-rock from Ardrishaig, Argyllshire. Albite=5% An; hornblende, γ=1.674, 2V=59°–62°; chlorite, β=1.633.

No. 19949: Blue-green hornblende-chlorite-epidote-albite-quartz-schist from south-west of Strachur, Loch Fyne, Argyllshire. Albite=5% An; hornblende, γ=1.682, 2V=60°; chlorite, β=1.640.

No. 14736: Blue-green hornblende-chlorite-epidote-oligoclase-schist from west-north-west of Craige, Aberfeldy, Perthshire. Oligoclase=24–28% An; hornblende, γ=1.663, 2V=81°; chlorite, β=1.609. Some hornblendes have an actinolite core. The hornblende and chlorite were analyzed (Table 6, *f*; Table 9).

No. 14735: Blue-green hornblende-garnet-oligoclase-quartz-schist from Craig an Eunaich, west of Dunkeld, Perthshire. Oligoclase =24% An; hornblende, γ=1.681, 2V=72°; garnet, a_o=11.62 A. The hornblende was analyzed (Table 6, *e*).

No. 28044: Blue-green hornblende-epidote-oligoclase-quartz-schist from Ben Vrackie, Pitlochry, Perthshire. Oligoclase=25% An; hornblende, γ=1.667, 2V=85°. The hornblende was analyzed (Table 6, *d*).

Group III: Epidiorites with green or brownish green hornblende.

No. 26320: Green hornblende-biotite-andesine-schist with a little garnet from Kinloch Rannoch, Perthshire. Andesine=33–36% An; hornblende, γ=1.675, 2V=81°; biotite, γ=1.632,

No. 48894: Brownish green hornblende-oligoclase-schist with a little biotite from a sill in Loch Tay Limestone, Cluny Bridge, Pitlochry, Perthshire. Oligoclase= 28–23% An; hornblende, γ=1.670, 2V=90°. The hornblende was analyzed (Table 6, *c*)

No. 48895: Brownish green hornblend-zoisite-oligoclase-rock from Killiecrankie, Perthshire. Oligoclase=18–28% An; hornblende, γ=1.670, 2V=86°; zoisite, α (min.) = 1.707, γ (max.)=1.718, 2V$_X$=123°–136°, r>v with regard to X. The hornblende was analyzed (Table 6, *b*).

No. 13700: Brownish green hornblende-biotite-oligoclase-quartz-schist from Dinnet west of Aboyne, Aberdeenshire. Oligoclase=21% An; hornblende, γ=1.691, 2V =65°; biotite, γ=1.655.

Group IV: Epidiorites with brown hornblende.

No. 4: Brown hornblende-andesine-rock with a little biotite from 3 miles east of Aboyne, Aberdeenshire. Andesine=36% An; hornblende, γ=1.681, 2V=80°.

No. 27316: Brown hornblende-garnet-clinopyroxene-andesine-quartz-schist from Banchory, Deeside, Kincardineshire. Andesine=48% An; hornblende, γ=1.692, 2V= 66°; clinopyroxene, 2V=57°; garnet, a_o=11.63 A. The hornblende and garnet were analyzed (Table 6, *a*; Table 10).

Note: The optical angle, 2V, of amphiboles is given in regard to X.

According to WISEMAN (1934), the calciferous amphibole in epidiorites of the chlorite and biotite zones is actinolite, poor in Al and alkalies (though he called it hornblende). Blue-green common hornblende richer in Al and alkalies occurs in epidorites of the almandine zone. The hornblende of the sillimanite zone is probably generally green, though in this respect WISEMAN's description is not clear. In the vicinity of granitic masses within the sillimanite zone, brown hornblende occurs. (WISEMEN gives no statement on the colors of hornblendes in the staurolite and kyanite zones.) Thus, in the Grampian Highlands, we have a progressive series of calciferous amphiboles as follows: actinolite —→ blue-green

common hornblende —→ green common hornblende —→ brown common hornblende. It is interesting that this progressive series is very similar to that in the central Abukuma Plateau.

All the specimens came from the Dalradian series, and their localities are distributed over Argyllshire, Perthshire, Kincardineshire and Aberdeenshire. The metamorphic grades of these rocks become higher generally toward the northeast in harmony with the thermal structure of the metamorphic terrian. Therefore, the classification of epidiorites in Table 5 into four groups, I, II, III and IV probably represents the increasing grade of metamorphism in this order, as commented below:

Group I: Epidiorites without amphibole and those with actinolite as a main component. These rocks came probably from the chlorite and biotite zones.

Group II: Epidiorites with blue-green common hornblende (i. e. hornblende with Z=bluish green or greenish blue). These rocks came probably from the almandine zone.

Group III: Epidiorites containing common hornblende with Z=green or brownish green without bluish tinge.

Group IV: Epidiorites containing common hornblende with Z=brown. The epidiorites of groups III and IV probably came from the sillimanite zone (and possibly also from the staurolite and kyanite zones).

2. Compositional Gap between Actinolite and Common Hornblende

In the central Abukuma Plateau, probably there exists a miscibility gap between actinolite and common hornblende in the transitional grade between zones A and B, as stated before. Is there such a gap in epidiorites of the Grampian Highlands? In this respect no mention is found in WISEMAN's description. Though we have too little data to give any definite statement on this problem, we would like to record some observation.

In our epidiorites Nos. 48893 and 14736, actinolite coexists with blue-green common hornblende. The hornblende is sometimes in parallel growth with, and sometimes in patches within, and sometimes in a rim around the actinolite. The boundary between them is always sharp, if we observe the thin sections tilted, if necessary, at an appropriate angle so that the boundary is parallel to the microscope axis. (The blue-green hornblende is deeper in color and higher in refractive indices than the associated actinolite.) Then, probably there is a compositional gap between the associated actinolite and common hornblende, and the gap would represent the existence of a miscibility gap.

3. Optic Properties

We prepared a $2V$–γ diagram for calciferous amphiboles in epidiorite specimens from the Grampian Highlands, as shown in Fig. 5. The relative positions of the fields in this case are similar to those in basic metamorphic rocks of the central Abukuma Plateau (Fig. 1). The actinolite field lies to the lower left of the blue-green hornblende field in both cases. The field of green, brownish green and brown hornblendes is smaller than, and lies generally in the upper part of the blue-green hornblende field in both cases.

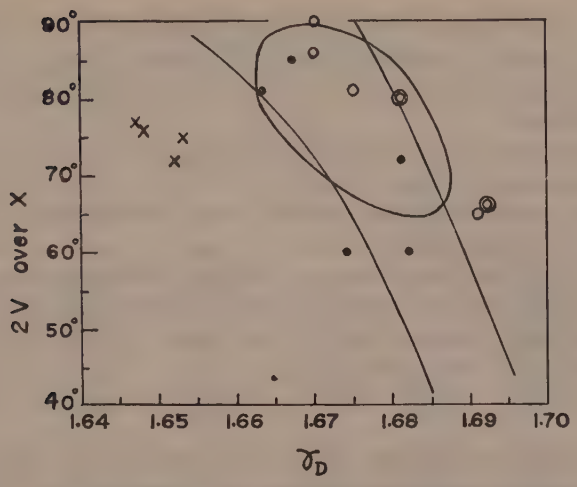


Fig. 5. Optic angle and index γ of calciferous amphiboles in epidiorites of the Grampian Highlands.
Cross: actinolite.
Solid circle: blue-green hornblende.
Open circle: green or brownish green hornblende.
Double circle: brown hornblende.
For comparison, the field boundaries in Fig. 1 are shown in this figure.

However, closer comparison of Figs. 1 and 5 indicates that the absolute positions of the field boundaries may differ to some extent. Probably the boundary between the actinolite and the blue-green hornblende fields has shifted toward the left in the case of Grampian epidiorites. The field of green, brownish green and brown hornblendes may have shifted toward the right in the same case. This suggests that there are some differences in chemical composition between calciferous amphiboles of the central Abukuma Plateau and those of the Grampian Highlands, even when they show similar colors.

4. Summary of Shidô's (1958) Results on the Relationship between Types of Metamorphism and Compositions of Metamorphic Hornblendes Produced

Regional metamorphisms are classified, in relation to their physical conditions, at least into three types, as follows: (1) central Abukuma type as is typically developed in the central part of the Abukuma Plateau (Miyashiro, 1958; Shidô, 1958), (2) Dalradian type as is typically developed in the main part of the Grampian Highlands, (3) glaucophanitic type. Shidô (1958) investigated the relationship between the types of metamorphism and compositions of the calciferous amphiboles produced. Her results may be summarized as follows:

(1) The alkali-bearing molecules of common hornblendes are glaucophane, edenite and sodatremolite, neglecting the $Mg \leftrightarrow Fe^{+2}$ and $Al \leftrightarrow Fe^{+3}$ substitutions. These molecules could be produced under some conditions from albite and some other minerals. Investigations of possible reactions revealed that their production should be promoted by higher solid pressures. Then, the alkali content of common hornblende should tend to increase with increasing solid pressure during

metamorphism. The actually observed alkali contents tend to increase in the following order: central Abukuma regional metamorphism ⟶ Dalradian metamorphism ⟶ glaucophanitic metamorphism. This order would represent increasing solid pressure.

(2) When the molecules are calculated after the method of SHIDÔ (1958), the following relations were found:

i) Glaucophane molecule is contained in some hornblendes of Dalradian and glaucophanitic metamorphisms.

ii) Hornblendes of central Abukuma regional metamorphism contain some amounts of sodatremolite molecule, those of Dalradian metamorphism contain generally larger amounts of it, and those of glaucophanitic metamorphism contain still larger amounts.

iii) Some hornblendes contain edenite molecule in any type of regional metamorphism.

Then, it is sodatremolite molecule that has made the greatest contribution to the increase in alkali content possibly with solid pressure.*

(3) The content of tschermakite molecule is practically independent of the type of metamorphism. The formation of tschermakite molecule from tremolite, chlorite and epidote, or from cummingtonite and calcic plagioclase should be promoted by higher solid pressure. Under higher solid pressures, however, the tschermakite molecule should tend to be transformed into garnet. These two effects should counteract each other.

(4) The content of tremolite molecule tends to decrease in the following order: central Abukuma regional metamorphism ⟶ Dalradian metamorphism ⟶ glaucophanitic metamorphism.

(5) The Mn content of hornblende tends to decrease in the following order: central Abukuma regional metamorphism ⟶ Dalradian metamorphism ⟶ glaucophanitic metamorphism, that is, possibly with increasing solid pressure. The increasing solid pressure should promote the formation of pyralspite, which probably deprive the associated hornblende of its Mn.

5. New Chemical Analyses of Epidiorite Hornblendes

Six hornblendes were separated from epidiorite specimens from the Grampian Highlands, and were analysed by H. HARAMURA. Among them, three were from group II, two were from group III, and one was from group IV. The results are shown in Table 6. The atomic ratios were calculated on the anhydrous basis of O=23, and the molecular compositions were calculated after the method of SHIDÔ, as shown in Tables 7 and 8.

For comparison WISEMAN's (1934) analyses of blue-green hornblendes are also shown in these tables. WISEMAN's hornblendes came from the entrance to the almandine zone, and hence probably they represent a lower grade than our analyzed hornblendes of group II. All these hornblendes are rich in Al.

---

* Recently, SEKI et al. (1959) found that amphiboles with compositions very close to the ideal edenite formula $NaCa_2Mg_5AlSi_7O_{22}(OH)_2$ occur widely and abundantly in metamorphic rocks of a certain part of the glaucophanitic terrane of the Sibukawa district, central Japan. (Such amphiboles had not been known to occur in nature before.) Thus, it has become clear that in some cases edenite molecule plays an important role for the high alkali contents of calciferous amphiboles prouduced by glaucophanitic metamorphism.

Table 6. Chemical analyses of hornblendes from epidiorites of the Grampian Highlands.

	Group IV	Group III		Group II				
	a	*b*	*c*	*d*	*e*	*f*	W_1	W_2
SiO_2	40.90	42.83	43.50	44.86	40.82	45.19	47.93	47.35
Al_2O_3	13.09	15.67	14.58	12.93	16.18	12.74	7.98	8.47
TiO_2	1.84	0.60	0.68	0.58	0.58	0.54	1.25	0.70
Fe_2O_3	2.90	2.09	2.10	2.13	3.77	2.25	2.95	2.83
FeO	17.81	12.83	12.26	12.79	16.78	9.60	17.79	17.16
MgO	7.50	10.61	10.93	11.18	6.49	13.79	7.08	8.83
MnO	0.22	0.23	0.21	0.25	0.21	0.24	0.20	0.25
CaO	11.56	11.30	11.23	11.72	10.29	11.62	10.45	10.16
Na_2O	1.30	1.66	1.73	1.58	1.87	1.33	1.36	0.65
K_2O	1.13	0.55	0.42	0.25	0.50	0.42	0.81	1.34
$H_2O(+)$	1.75	1.78	2.20	1.98	2.45	2.11	2.07	2.05
$H_2O(-)$	0.00	0.05	0.00	0.00	0.00	0.00	0.20	0.00
P_2O_5	0.09	0.01	tr.	0.03	0.01	0.05	n.d.	n.d.
Total	100.09	100.21	99.84	100.28	99.95	99.88	100.07	99.79
α_D	1.660	1.649	1.650	1.646	1.658	1.637	1.673	1.663
β_D	n. d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.686	1.677
γ_D	1.692	1.670	1.670	1.667	1.681	1.663	1.695	1.687
$2V_X$	66°	86°	90°	85°	72°	81°	n.d.	n.d.
$c \wedge Z$	27°	18°	17°	17°	20°	20°	19°	19°
X	yellow	nearly colorless	very pale yellow	pale yellow	pale yellow	very pale yellow	yellow-green	yellow-green
Y	brown	yellowish green	green	green	bluish green	light green	grass green	green
Z	brown	light green	light yellow-green	bluish green	blue-green	light blue-green	blue-green	blue-green
Absorp.	Z=Y>X	Z=Y>X	X>Z>X	Z=Y>X	Z=Y>X	Y>Z>X		
Disp.	r>v	r>v	r>v	r>v	r>v	r>v		

Host-rocks of the hornblendes

a: Brown hornblende-garnet-clinopyroxene-andesine-quartz-schist from Banchory, Deeside (Specimen No. 27316).

b: Brownish green hornblende-zoisite-oligoclase-rock from Killiecrankie, Perthshire (Specimen No. 48895).

c: Brownish green hornblende-oligoclase-schist with a little biotite from a sill in Loch Tay Limestone, Perthshire (Specimen No. 48894).

d: Blue-green hornblende-epidote-oligoclase-quartz-schist from Ben Vrackie, Perthshire (Specimen No. 28044).

e: Blue-green hornblende-garnet-oligoclase-quartz-schist from Craig an Eunaich, Perthshire (Specimen No. 14735).

f: Blue-green hornblende-chlorite-epidote-oligoclase-schist from west-north-west of Craige, Perthshire (Specimen No. 14736).

W_1: Garnet-biotite-epidote-albite-amphibolite from 0.2 mile N 51° E from northern end of Loch-na-Craige near Achahoish, South Knapdale (WISEMAN, 1934, p. 382).

W_2: Biotite-epidote-albite-amphibolite from the same locality as W_1 (WISEMAN, 1934, p. 383).

Note: The analyses of *a*—*f* were made by Hiroshi HARAMURA. For more detailed descriptions of the host-rocks, see Table 5.

Table 7. Atomic ratios calculated from the hornblende analyse o Table 6 on the anhydrous basis of O=23.

	Group IV	Group III		Group II				
	a	*b*	*c*	*d*	*e*	*f*	W_1	W_2
Si	6.206	6.258	6.379	6.545	6.167	6.535	7.168	7.072
Al^{IV}	1.794	1.742	1.621	1.455	1.833	1.465	0.832	0.928
Al^{VI}	0.546	0.956	0.898	0.767	1.475	0.707	0.575	0.563
Ti	0.210	0.066	0.075	0.064	0.066	0.059	0.141	0.079
Fe^{+3}	0.332	0.230	0.232	0.233	0.428	0.245	0.332	0.318
Fe^{+2}	2.259	1.567	1.503	1.560	2.119	1.160	2.224	2.143
Mg	1.695	2.310	2.387	2.430	1.438	2.971	1.577	1.964
Mn	0.028	0.028	0.026	0.031	0.027	0.030	0.025	0.031
Ca	1.878	1.768	1.764	1.831	1.665	1.800	1.673	1.625
Na	0.383	0.470	0.491	0.447	0.548	0.374	0.393	0.188
K	0.219	0.102	0.079	0.047	0.096	0.078	0.154	0.225
(Na+K)	0.602	0.572	0.570	0.494	0.644	0.452	0.547	0.443

Table 8. Molecular compositions of the analyzed hornblendes of Table 6, calculated after the method of SHIDÔ (1958).

	Group IV	Group III		Group II				
	a	*b*	*c*	*d*	*e*	*f*	W_1	W_2
Tiam	0.420	0.132	0.150	0.128	0.132	0.118	0.282	0.158
Cum	0.280	0.628	0.484	0.340	0.500	0.688	——	0.392
Ts′	1.405	1.898	1.808	1.600	2.360	1.523	0.877	1.232
Ca-cum	——	——	——	——	——	——	0.202	——
St′	0.208	0.300	0.460	0.336	0.840	0.112	0.376	0.664
Gl	——	——	——	——	——	——	1.436	0.444
Ed′	0.498	0.422	0.340	0.326	0.224	0.396	——	——
Tr	5.188	4.620	4.756	5.268	3.944	5.160	4.828	5.108

Investigation of these new analyses leads to the following conclusions:

(1) The tendency of increase of the alkali content of hornblende with metamorphic grade was found to be very clear in the central Abukuma Plateau, while it is not so clear in the Dalradian epidiorites. In the grade where hornblende begins to appear, the Dalradian hornblendes have evidently higher alkali contents than the central Abukuma hornblendes. In high grades, however, most of the Dalradian hornblendes have alkali contents comparable to the highest possible values for each metamorphic grade in the central Abukuma Plateau. On the average, Dalradian hornblendes have a large alkali content than central Abukuma ones, whereas they have a much smaller alkali content than common hornblendes produced by glaucophanitic metamorphism. (The larger content of alkalies in common hornblendes produced by glaucophanitic metamorphism may be partly due to the very sodic compositions of the associated plagioclases.)

(2) Our newly analyzed epidiorite hornblendes do not contain glaucophane molecule, while WISEMAN's hornblendes do contain. As WISEMAN's came from a

lower grade than ours, it is conceivable that glaucophane molecule may tend to decrease with increasing metamorphic grade. (Note that the $Mg \leftrightarrow Fe^{+2}$ and $Al \leftrightarrow Fe^{+3}$ substitutions are neglected, and hence glaucophane molecule in this case include riebeckite molecule.)

(3) All the analyzed Dalradian hornblendes contain sodatremolite molecule. On the other hand, in the central Abukuma Plateau, hornblendes from zone B do not contain it, and those from zone C do contain. This is in harmony with SHIDÔ's statement.

(4) Dalradian hornblendes have generally smaller amounts of tremolite molecules than central Abukuma hornblendes, as stated by SHIDÔ (1958).

(5) The former statement on the Mn contents of hornblendes has been confirmed, as the following figures indicate:

Dalradian hornblendes:

Group II: 0.20, 0.21, 0.24, 0.25, 0.25% (by weight).

Groups III and IV: 0.21, 0.22, 0.23%.

Central Abukuma hornblendes:

Zone B: 0.18, 0.33, 0.37, 0.41, 0.44, 0.69%.

Zone C: 0.19, 0.21, 0.24, 0.28, 0.29, 0.30, 0.32, 0.34, 0.43%.

IV. Some Other Minerals of the Grampian Highlands

1. Plagioclase

The epidiorites of groups I and II always contain some epidote, and hence the plagioclase would be in equilibrium with it. Then, the composition of the plagioclase is an indicator of the physical conditions prevailing. The compositions determined on the basis of CHAYE's (1952) curve are:

Group I: 3 —5% An

Group II: 5—30% An

In epidiorites of groups III and IV, epidote is absent, and hence the composition of the plagioclase mainly depends on that of the host-rock. The compositions of the plagioclase in these groups are generally in the range: 20—50% An. These figures are in harmony with WISEMAN's.

2. Epidote

In some epidiorites of group I, the epidote grains are practically homogeneous and ferriferous (with about 30% Fe-molecule), while in other epidiorites, the epidote grains are zoned with decreasing retardation and increasing $2V_X$ toward the margin. This zoning represents a decrease in iron content toward the margin probably in response to progressive metamorphism. Zoning is generally more marked in larger grains. Small grains may be almost homogeneous with compositions similar to that of the margin of the associated larger grains.

In epidiorites of group I, the composition range of epidote is roughly 0—35 % Fe-molecule, while in epidiorites of group II, the composition range is roughly 0—20% Fe-molecule. If these observations may be generalized, the iron-richer end of the composition range tends to become lower with progressive metamorphism.

Rocks of groups III and IV have no epidote, but specimen No. 48895 (group III) has zoisite.

3. Chlorite and its Paragenetic Relations

A chlorite was separated from an epidiorite (No. 14736) of group II, from which the associated blue-green hornblende was also separated and analyzed. An analysis of the chlorite is shown in Table 9. The Mg—Fe^{+2} partition between the associated chlorite and hornblende is as follows:

	FeO/MgO (by weight)
Chlorite	0.654
Hornblende	0.697

Table 9. Analyses of chlorites from epidiorites of the Grampian Highlands

	a	*b*
SiO_2	28.2	26.50
Al_2O_3	24.9	23.08
TiO_2	—	0.20
Fe_2O_3	0.2	1.59
FeO	26.8	14.49
MgO	10.9	22.17
MnO	—	0.15
CaO	—	0.28
Na_2O	—	0.19
K_2O	—	0.00
$H_2O(+)$	9.0	11.26
$H_2O(-)$		0.28
Tot a	100.0	100.19

a: Calculated composition of chlorite from chlorite-albite-schist, eastern side of Eilean Traighe, west of Tayvallich. β=1.637; opt. negative. WISEMAN (1934, p. 362).

b: Chlorite from blue-green hornblende-chlorite-epidote-oligoclase-schist (Specimen No. 14736), WNW of Craige, Perthshire. Analyzed by H. HARAMURA. d_{005}=2.831Å, d_{007}=2.022Å; β=1.609, $\gamma-\alpha$=0.009; negative elongation. The associated hornblende was analyzed (Table 6, *f*).

WISEMAN (1934) calculated the composition of a chlorite from the bulk chemical composition of its host rock of the "low-grade zone" (corresponding to our group I). This composition, quoted in Table 9, is very similar to that of the above chlorite except the FeO/MgO ratio. WISEMAN further found that in a low-grade epidiorite in which the FeO/MgO ratio of the chlorite is vere slightly smaller than unity, the same ratio of the associated actinolite is 0.65. Thus, the chlorite has a much larger FeO/MgO ratio than the associated actinolite, whereas we showed above that the chlorite has a much smaller FeO/MgO ratio than the associated blue-green hornblende.

This difference is probably mainly due to a difference in character between actinolite and hornblende. Hornblende appears to like iron much better than actinolite does. A similar relation is noticed between clinopyroxene (diopside-hedenbergite) and the associated actinolite or hornblende. Actinolite usually has a lower FeO/MgO ratio than the associated clinopyroxene, whereas hornblende usually has a higher FeO/MgO ratio than the associated clinopyroxene.

4. Garnet

A pyralspite garnet was separated from an epidiorite (No. 27316) of group IV, from which the associated hornblende was also separated and analyzed. The analysis of the garnet is shown in Table 10. It is almandine rather rich in CaO. The garnet has a much higher FeO/MgO ratio than the associated hornblende.

Table 10. Analyses of pyralspite garnets from epidiorites of the Grampian Highlands.

	a	*b*
SiO_2	38.44	35.91
Al_2O_3	20.62	22.13
TiO_2	n. d.	0.96
Fe_2O_3	7.39	1.73
FeO	17.09	25.04
MgO	2.51	1.89
MnO	4.22	1.87
CaO	10.08	10.13
Na_2O	n. d.	0.08
K_2O	n. d.	0.10
$H_2O(+)$	n. d.	0.46
$H_2O(-)$	n. d.	0.14
Total	100.35	100.44

a: Garnet from garnet-biotite-clinozoisite-albite-amphibolite, 0.2 mile N 51°E from northern end of Loch-na-Craige, near Achahoish (at the commencement of the garnet zone). WISEMAN (1934, p. 388).

b: Garnet from brown hornblende-garnet-clinopyroxene-andesine-quartz-schist (Specimen No. 27316), Banchory, Deeside, Kincardineshire. Analyzed by H. HARAMURA. Unit cell edge $a_o = 11.63$ Å. Mn: Fe^{+2}: Mg = 6.2 : 82.6 : 11.1. The associated hornblende was analyzed (Table 6, *a*)

WISEMAN (1934) gave an analysis of a garnet from the lowest-grade part of the almandine zone, that is, from a much lower grade than in the present case. His result is also shown in Table 10. His garnet is similar to ours, except its Fe_2O_3, FeO, and MnO contents. The difference would show the tendency of decrease in MnO and of increase in FeO with increasing grade of metamorphism. It is not clear whether the difference in Fe_2O_3 content is real or apparent.

References Cited

CHAYES, F. (1952) Relation between composition and indices of refraction in natural plagioclase. *Amer. Jour. Sci.*, Bowen Vol., pp. 85–105.

HARRY, W. T. (1950) Aluminium replacing silicon in some silicate lattices. *Mineralog. Mag.*, Vol. 29, pp. 142–149.

MIYASHIRO, A. (1958) Regional metamorphism of the Gosaisyo-Takanuki district in the central Abukuma Plateau. *Jour. Fac. Sci., Univ. Tokyo*, Sec. II, Vol. 11, pp. 219–272.

SEKI, Y., AIBA, M., and KATO, C. (1959) Edenites from Sanbagawa crystalline schists in the Sibukawa district, central Japan. *Japan. Jour. Geol. Geogr.* (in press).

SHIDÔ, F. (1958) Plutonic and metamorphic rocks of the Nakoso and Iritôno districts in the central Abukuma Plateau. *Jour. Fac. Sci., Univ. Tokyo*, Sec. II, Vol. 11, pp. 131–217.

SNELLING, N.J. (1957) Notes on the petrology and mineralogy of the Barrovian metamorphic zones. *Geol. Mag.*, Vol. 94, pp. 297–304.

WISEMAN, J. D. H. (1934) The central and southwest Highland epidiorites: a study in progressive metamorphism. *Quart. Jour. Geol. Soc. London*, Vol. 90, pp. 354–417.

MOLLUSCAN FAUNA OF THE PLIOCENE SANNOHE GROUP OF NORTHEAST HONSHU, JAPAN

1. The Faunule of the Kubo Formation

By

Kiyotaka CHINZEI

With Three Plates

Contents

Introduction 103
Outline of Stratigraphy 104
Molluscan Assemblages in the Kubo formation 104
Geological Significance of the Faunule 108
Description of Species 109
References 129

Introduction

Two different types of the Pliocene molluscan fauna are known from Northeast Japan, that is, the so-called Omma-Manganji fauna (OTUKA, 1936) in the Japan Sea side and the Tatsunokuchi (Tatunokuti) fauna (NOMURA, 1938) in the Pacific side. The former is characterized by cold deep water elements and the latter by shallow water ones. The Sannohe group is the Pliocene deposits distributed in the northern margin of the Kitakami Mountains, in the Pacific side of Northeast Honshu. The fauna of the group was listed first by HAYAKAWA et al. (1954), but little attention has hitherto been paid to the molluscan assemblages, except for HATAI's (in HANZAWA, 1954) and KITAMURA's (1959) studies which pointed out their similiarity to the "Omma-Manganji fauna".

Although the Sannohe group was deposited in the Pacific side, or in the same terrain as the Tatsunokuchian formations, it is characterized by the "Omma-Manganji" type elements. It is therefore important to define the faunal character for the further discussion of the geological peculiarity of the group.

By dividing the fossil-bearing beds of the group into five horizons, the writer (1958 b, p. 534) clarified that the "Omma-Manganji" type assemblages predominate in the upper two horizons; the upper Togawa, and the lower Kubo formations. In this paper the writer presents the first detailed account of the molluscan fossil faunule contained in the Kubo formation of the Sannohe group. He intends to discuss in the near future the faunule of the Togawa formation, which is peculiar in its mixed character of the "Omma-Manganji" and Tatsunokuchi type elements.

Received June 15, 1959.

Acknowledgements:—The writer wishes to express his hearty thanks to Professor Fuyuji TAKAI of the Institute for his continuous guidance and encouragement. Thanks are due to Dr. Katsura OYAMA of the Geological Survey of Japan and Dr. Tetsuro HANAI of the Institute for their invaluable suggestions, and to Mr. Masuoki HORIKOSHI and Miss Reiko FUSEJIMA for reading the manuscript. He is also indebted to Dr. Tokio SHIKAMA, Dr. Kinichi SAKURAI and Mr. Sunao OGOSE for their kind advices.

Outline of Stratigraphy

The Sannohe group (CHINZEI, 1958b) is mainly composed of sandstone and siltstone and their alternation; its thickness attains about 1,100m at the maximum. The group overlies the Miocene Shiratorigawa group with a conformity, and is covered by the Pleistocene Kamikita group with an angular unconformity. The group can be divided into four formations as shown in fig. 2.

The group consists mostly of marine beds. It shows a single large cycle of sedimentation beginning with shell-limestone and sandstone and ending with an alternation of non-marine sands, silts and gravels. The main body of the group is made up of thick, monotonous beds of siltstone and sandstone.

Figure 1. Location (hatched area: older sedimentary and plutonic rocks of the Kitakami Mountains).

The molluscan fossils described here were collected from the Kamassawa alternation, the lower member of the Kubo formation. The member is composed of an alternation of medium-grained sandstone and gray siltstone; it shows a gradual lateral change of rock facies into massive very fine-grained sandstone. The molluscan fossils are contained in the very fine-grained sandstone and are accompanied by a considerably large amount of sponge spicules, ostracods, foraminifers and echinoids.

Molluscan Assemblages in the Kubo Formation

The species, here identified in three localities*, are thirty-nine in total; of them twenty-five species are gastropods, thirteen pelecypods, and one scaphopod. Among these thirty-nine species, twelve are conspecific to the Recent forms, and

* Loc. 1: a small cliff, 100 m west of Ochiai; Loc. 2: a river-side cliff, 150 m south of Ochiai; Loc. 3: a small exposure in the stream, 700 m northwest of Kosaka: all in Kintaichi-mura, Ninohe-gun, Iwate Prefecture, Japan.

Species	Number of specimen			"Omma-Manganji" Localities*								
	Loc. 1	Loc. 2	Loc. 3	Manganji (mainly by KANEHARA, 1940 b)	Omma (HATAI and NISIYAMA, 1939)	Nozaki (OTUKA, 1935 b)	Sawane (YOKOYAMA, 1926 a)	Nishiyama (ITOIGAWA, 1958)	Haizume (*Ibid.*)	Nikkogawa (NOMURA, 1937)	Daishaka (NOMURA and HATAI, 1935 b)	Hamada (OTUKA, 1939)
Alvania awa CHINZEI, n. sp.	7						+					+
Turritella nipponica YOKOYAMA	115	55	3	+	+	+	+	+	+			○+
Epitonium (*Boreoscala*) *echigonum* KANEHARA	2			○		+		○				
Natica (*Tectonatica*) *russa* GOULD	3	22				○					+	○
Fusitriton oregonensis (REDFIELD)		3	2	○					○			
Trophonopsis aff. *beringi* (DALL)	1										+	
Trophonopsis sp.		1										
Neptunea otukai CHINZEI n. sp.	1+5	1				+						
Coraeophos meisensis ninohensis CHINZEI, n. subsp.	2+5	1										
"*Macron*" *nipponensis* CHINZEI, n. sp.		1										
Olivella sp.	1											
Fulgoraria sp.			1									
Admete lischkei (YOKOYAMA)		1	2	+	+		○+	+	+			
Suavodrillia oyamai CHINZEI n. sp.	3			+	+							
Antiplanes (*Rectiplanes*) *sadoensis* (YOKOYAMA)	16	3		+	+		○	○+	○+	○		
Propebela cf. *nakamurai* (ONOYAMA)	1											
Propebela cf. *kurodai* (ONOYAMA)	1				○					○		
Propebela cf. *turricula* (MONTAGUE)	2						+	○				
Propebela sp.	1											
Mohnia sp.	3											
Menestho araii (OTUKA)	6											○
Menestho iwatensis CHINZEI n. sp.	1				+							
Menestho nomurai CHINZEI n. sp.		1										
Odostomia (*Evalea*) *aleutica* DALL and BARTSCH	1											
Liloa sp.	1											
Siphonodentalium sp.	15+	10+										
Nuculana sp.			15									
Glycymeris derelictas YOKOYAMA	10	1	2		○						+	
Nucinella (*Huxleyia*) *ochiaiensis* CHINZEI, n. sp.	3											
Crenella yokoyamai NOMURA	1				+		+	○	○			
Chlamys cf. *cosibensis* (YOKOYAMA)	1						○	+	+		○	○
Venericardia ferruginea ochiaiensis CHINZEI	300+	3		+	+		+		+		+	+
Lucinoma acutilineatum (CONRAD)	9	2	1		○	○	○	+				
Clinocardium iwatense CHINZEI n. sp.		5		+	+		+		+			+
Serripes sp. cf. *notabilis* (SOWERBY)	1											
Dosinia sp.	1											
Macoma calcarea (GMELIN)		2	3									○
Panomya ampla DALL	3+	2										
"*Pandora*" sp. cf. *pulchella* YOKOYAMA	5+	3+	3+	○					○			○

*) ○ Occurrence of conspecific forms with the present localities.
+ Occurrence of allied forms.

ten of the rest are new to science and are now found only in the present localities. Generally, *Turritella nipponica* YOKOYAMA and *Venericardia ferruginea ochiaiensis* CHINZEI are especially abundant; and the subordinate common species are as follows: *Natica russa* GOULD, *Coraeophos meisensis ninohensis* CHINZEI n. subsp., *Antiplanes sadoensis* (YOKOYAMA), *Glycymeris derelicta* (YOKOYAMA), *Lucinoma acutilineatum* (CONRAD), *Clinocardium iwatense* CHINZEI n. sp., *Macoma calcarea* (GMELIN), "*Pandora*" sp. cf. *pulchella* YOKOYAMA, etc.

However, the constituents of the assemblages are considerably different by locality. In Loc. 1, *Turritella nipponica* and *Venericardia ferruginea ochiaiensis* are both very abundant, and in Loc. 2, *Turritella nipponica*, *Natica russa* GOULD, *Clinocardium iwatense* CHINZEI n. sp. are predominant, whereas *Venericardia* is found only rarely. In Loc. 3, both the numbers of species and individuals are poor, and the constituents are quite different from other two localities, namely, *Turritella* and *Venericardia* are almost absent, *Nuculana* sp. is the representative form, and *Fulgoraria* sp. and *Serripes* cf. *notabilis* (SOWERBY) are limitedly found in this locality.

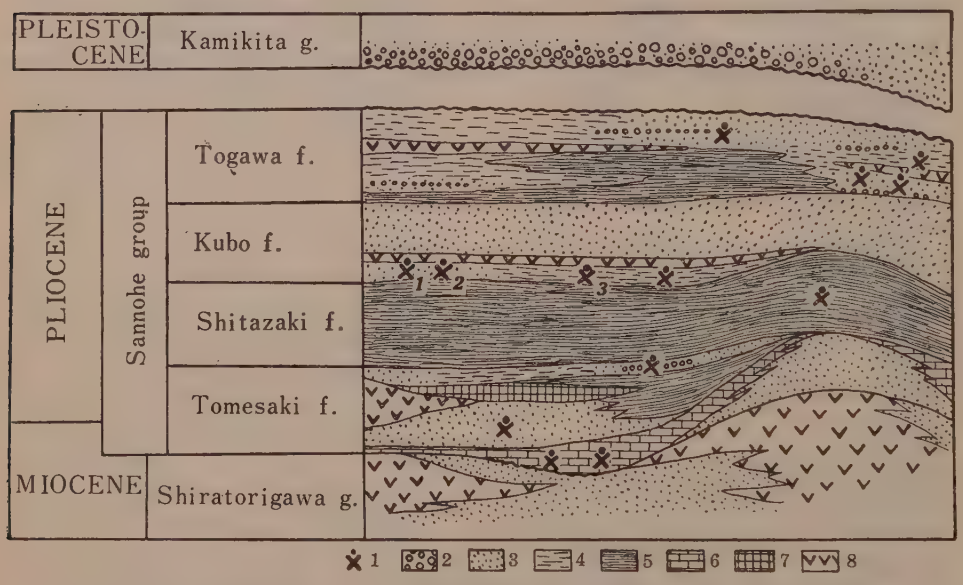


Figure 2. Stratigraphic section of the Sannohe group showing the molluscan fossil-bearing horizons.

1. fossil locality; 2. conglomerate and gravels; 3. sandstone; 4. alternation of sandstone and siltstone; 5. siltstone; 6. shell-limestone; 7. diatomaceous rock; 8. volcanic rock and tuff.

Locality numbers are shown in Italics.

The fossils are sporadically found in massive fine-grained sandstone, and many pelecypods occur with conjoined valves. The minute sculptures of shell-surface or even the protoconchs of certain gastropods are well preserved. In other words, there is no indication of defacement by transportation nor evidence of accumulation. From these facts it can be inferred that the assemblages are authocthonous or subauthocthonous.

The horizontal distribution of the twelve Recent species in these assemblages in the western Pacific is shown in table 2.

The species listed in table 2 inhabit the area north of about Lat. 36° N, which is under the influence of the cold Oyashio current; that is to say, they live in the oceanic waters in the temperate zone of the northwestern Pacific. *Boreoscala*, *Menestho*, *Trophonopsis*, *Neptunea*, *Propebela*, etc. are also cold water elements.

Table 2.

Species	Geographical distribution
Turritella nipponica	Lat. 39°N
Natica russa	39–71
Fusitriton oregonensis	38–59
Admete lischkei	36–46
Propebela turricula	45?
Odostomia aleutica	54
Crenella yokoyamai	35?
Lucinoma acutilineatum	?
Serripes notabilis	36–37 (Japan Sea side)
Macoma calcarea	33–72
Panomya ampla	50–68
Pandora pulchella	36–38 (Japan Sea side)

Judging from the prevalent occurrence of *Boreoscala*, *Trophonopsis*, *Fulgoraria*, *Admete*, *Antiplanes*, *Suavodrillia*, *Venericardia* and some other forms, as well as the lack of characteristic species of shallow water inhabitants, it may be concluded that the present assemblages show the faunal aspect of the lower shelf.

The definition of the "Omma-Manganji fauna" was given by OTUKA (1939) for the first time, as "a fauna of the Japan Sea during the Pliocene". It is said to be composed of cold deep water inhabitants (OTUKA, 1936; HATAI and NISIYAMA, 1939; KANEHARA, 1940), and is characterized by the predominance of certain forms of gastropods such as *Turritella*, *Fusitriton*, *Natica*, *Admete*, *Antiplanes*, "*Lora*" and *Suavodrillia*, accompanied by *Patinopecten*, *Chlamys*, *Astarte* and some other pelecypods. This presents a remarkable contrast to the underlying Miocene fauna of the Japan Sea side where the fauna is represented by *Ancistrolepis*, *Serripes*, *Panomya*, *Mya*, etc.

The Kubo faunule shows a close resemblance to the "Omma-Manganji fauna". About 60 percent of the constituents of the faunule are common with the hitherto known assemblages, if not strictly identical. They are, for example, *Epitonium* (*Boreoscala*) *echigonum* KANEHARA, *Menestho* spp., *Fusitriton oregonensis* (REDFIELD), *Suavodrillia oyamai* CHINZEI n. sp., *Antiplanes sadoensis* (YOKOYAMA), *Propebela* spp., *Venericardia ferruginea ochiaiensis* CHINZEI, "*Pandora*" cf. *pulchella* YOKOYAMA (see Table 2). However, such species as *Menestho nomurai* CHINZEI n. sp., "*Macron*", *Coraeophos*, *Nucinella* (*Huxleyia*), *Panomya* are still unknown in the "Omma-Manganji fauna".

In spite of the general resemblance between the faunule and the "Omma-Manganji fauna", the degree of similarity* of the faunule to each assemblage is almost less than 10 percent except for the Hamada formation (17 %) of the Shimokita Peninsula. In other words, the faunal constituents in the different localities of the "Omma-Manganji fauna" are respectively constructed of the different assemblage. This fact indicates the heterogeneity of the fauna. In the present stage of our knowledge, the meaning of the faunal heterogeneity is not known precisely, hence, detailed stratigraphical, paleoecological and paleogeographical studies are required.

Moreover, the faunule of the Kubo formation contains certain forms, such

---

* The degree of similarity (A) is calculated by the following formula (SAKAKURA, 1935):—

$$A = \frac{x}{(a+b)-x} \times 100$$

(x=number of species common between the two faunas or assemblages to be compared; a, b= numbers of species of the two faunas)

as, *Neptunea otukai* CHINZEI n. sp., *Suavodrillia oyamai* CHINZEI n. sp., *Venericardia ferruginea ochiaiensis* CHINZEI, *Clinocardium iwatense* CHINZEI n. sp., each of which is closely related to, but disinctly different from, species in the "Omma-Manganji fauna" in other localities. The corresponding species in "Omma-Manganji fauna" are as follows: *Neptunea uwasoensis* (OTUKA), *Suavodrillia declivis* (v. MARTENS), *Venericardia ferruginea* (CLESSIN) and *Clinocardium ciliatum* (FABRICIUS) respectively. The abnormal thickening of shells of some forms also deserves attention, for example, *Neptunea otukai* CHINZEI n. sp., "*Macron*" *nipponensis* CHINZEI n. sp., *Coraeophos meisensis ninohensis* CHINZEI n. subsp., *Venericardia ferruginea ochiaiensis* CHINZEI and *Clinocardium iwatense* CHINZEI n. sp.

The occurrences of *Coraeophos* and "*Macron*" are highly interesting in considering their geographical and stratigraphical distribution. The occurrence of "*Macron*" is limited in the Miocene to Recent of the west coast of North America. Although the generic designation of the present specimen to *Macron* is still tentative, the occurrence of the allied form in the western Pacific is worth paying attention. *Coraeophos*, as discussed in the following lines, has hitherto been reported only from the Miocene of northern Pacific region, or some localities of the upper Miocene of Japan and Korea, and the Miocene Astoria formation of the west coast of North America. *C. meisensis ninohensis* CHINZEI n. subsp. is the first occurrence of the genus in the Pliocene deposits, and is considered as a relict of the Miocene species.

Geological Significance of the Faunule

The Sannohe group can be correlated with the Sendai group of the environs of Sendai and Ichinoseki cities, which are said to have been deposited as the thin veneer on the western margin of the Kitakami Mountains.

Although they were deposited in the same terrain, between the Kitakami Mountains and the central part (Ôu Mountain Range) of the so-called Uetsu geosyncline of the Northeast Japan, the Sannohe group differs in many respects from the Sendai group. The Sendai group is characterized by thin nonmarine deposits intercalated with many lignite seams, and can be subdivided into several formations by unconformities. Only a thin marine bed which contains the shallow sea type Tatsunokuchi fauna is present in the middle part of the Sendai group. On the contrary, as already stated by the writer (1958 b), the Sannohe group consists mostly of marine beds, and shows a single large cycle of sedimentation. The group is extraordinarily thick as compared with the Sendai group, as the maximum thickness of the former is 1,100 m in contrast to more or less 200m of the latter.

Considering the above facts and the geological structure of the Sannohe group, the writer has an opinion that the group may have been deposited filling the considerably deep trough between the stable Kitakami Mountains and the Ôu Mountain Range. In this view, the occurrence of an authocthonous deep water assemblage in the middle horizon of the group is interesting.

The faunal similarity to the "Omma-Manganji fauna" suggests that the marine environments were not dissimilar between the northern end of the Kitakami Mountains and the geosynclinal areas of the Japan Sea side of Northeast Japan. However, the occurrences of certain peculiar forms, which differ in some characters from their affinities of the "Omma-Manganji fauna" in other localities, may suggest the paleogeographical and paleoecological differentiation of the

area caused by the initial uplift of the Ôu Mountain Range.

Description of Species

Family Rissoidae

Genus *Alvania* Risso 1820.

Alvania awa Chinzei, n. sp.

Plate X, figures 1~4.

Description: Shell small, elongate-oval. Protoconch one and a half whorls, prominent but small, rounded, smooth; whorls 3 or 4, shouldered at about 1/3 from the upper suture, upper surface of the shoulder concave; suture channeled; surface ornamented with fairly ridged, triangular axial ribs and regular, slender, rounded spiral cords. The penultimate and the third whorls ornamented with 17 to 19 axial ribs and 3 spiral cords. Axial ribs 26 to 30 on the body whorl; which grow successively more closely spaced and weaken towards the aperture; and each rib becomes obsolete towards the base. Spiral cords 8 or 9, interspaces of cords become narrower towards the base. The uppermost cord forms the shoulder; intersections of the axial ribs and the cords nodulated especially at the shoulder. Aperture entire, broadly oval, anterior and posterior ends form nearly a right angle respectively; outer lip curves as strong as inner lip; inner surface of both lips smooth. Umbilicus funnel-shaped.

Remarks: This species is characterized by its low spire, well inflated oval body whorl, nodulously cancellated surface sculpture, and distinct shoulders at upper 1/3 of the whorl.

Alvania carpenteri Weinkauff is quite similar to *awa*, but the two can be distinguished by the number of both axial and spiral sculptures; moreover, the former has no distinct nodes on the intersections of axial and spiral sculptures. *A. tokyoensis* (Pilsbry) is another allied species, but it is different from the new one in having higher spire and less inflated body whorl.

With the small elongate-oval outline and cancellated sculpture, the new species resembles *A. akibai* (Yokoyama) and *A. maya* (Yokoyama), which were reported from the Sawane formation of Sado Island and are important elements of "Omma-Manganji fauna", but the new species can easily be discriminated from the latters by its distinct shoulders. It is allied to *A. sitta* (Yokoyama) which is also a Sawane species, in having distinct shoulders and nodulated cancellous sculpture; however, it differs from the latter in the larger numbers of axial ribs and spiral cords.

Measurements (in mm):

Specimen	Reg. No.*	Height	Maximum diameter	Height of body whorl	Length of aperture	Number of whorls
Holotype	CM 8513	2.8	1.9	1.9	1.1	3.5
Paratype	CM 8514	2.7	1.7	1.9	1.0	3
,,	CM 8515	2.6	1.7	1.8	1.0	3
,,	CM 8516	2.6	1.8	1.7	1.0	3
,,	CM 8517	2.4	1.7	1.6	1.0	3
,,	CM 8518	2.0	1.5	1.4	0.9	2.5
,,	CM 8519	2.6	1.8	1.7	1.1	3

Locality: Loc. 1 (common).

* The whole specimens here described are preserved in the Institute of Geology, Faculty of Science, University of Tokyo.

Family Turritellidae

Genus *Turritella* LAMARCK 1799.

Turritella (*Neohaustator*) *nipponica* YOKOYAMA

Plate X, figure 14.

1920. *Turritella nipponica* YOKOYAMA, *Jour. Coll. Sci. Imp. Univ. Tokyo, Vol. 39, Art. 6*, p. 71, pl. 4, fig. 16.
1950. *Turritella nipponica*, HATAI and KOTAKA, *Jour. Geol. Soc. Japan, Vol. 56, No. 654*, pp. 102–103, text-figs. 1a, 1b.
1952. *Turritella* (*Neohaustator*) *nipponica*, IDA, *Geol. Surv. Japan, Rept. No. 150*, pp. 47–50, pl. 3, fig. 7.

Remarks: Many well preserved specimens were collected at Locs. 1 and 2. Their spiral ornamentation has the features characteristic to *T. nipponica*, having 4 spiral cords, the lower two of which are more prominent, and having trapezoid whorl profil. In Northeast Japan, *T. nipponica* has been reported as fossils only from the Pliocene Hamada formation, one of the "Omma-Manganji" localities, of the Shimokita Peninsula and the Pleistocene of Anden, Oga Peninsula, Akita Prefecture. CM 8521–8523, CM 8587.

Locality: Loc. 1 and Loc. 2 (both very abundant).

Family Epitoniidae

Genus *Epitonium* RÖDING 1798.

Epitonium (*Boreoscala*) cf. *echigonum* KANEHARA

Plate X, figure 13.

cf. 1940 a. *Epitonium* (*Boreoscala*) *yabei* NOMURA var. *echigonum* KANEHARA, *Bull. Imp. Geol. Surv. Japan, Vol. 27, No. 2*, pp. 14–16, pl. 4, figs. 6a, 6b.
cf. 1940 b. *Epitonium* (*Boreoscala*) *yabei echigonum*, KANEHARA, *Japan. Jour. Geol. Geogr., Vol. 17, Nos. 1–2*, p. 128, pl. 7, figs. 13–16.

Remarks: Two broken specimens were obtained. They are characterized by 12 straight varices and 6 or 7 rounded low spiral cords. The species has hitherto been reported from Manganji, Akita Pref., the type locality of the "*Manganjian fauna*" of OTUKA (1936), and from the Takezawa oil field of Niigata Pref., both Pliocene in age. CM 8524, 8525.

Locality: Loc. 1 (rare).

Family Naticidae

Genus *Natica* SCOPOLI 1777.

Natica (*Tectonatica*) *russa* GOULD

Plate X, figure 8.

1919 b. *Cryptonatica aleutica* DALL, *Proc. U. S. Nat. Mus., Vol. 56*, p. 352.
1921. *Cryptonatica aleutica*, DALL, *Bull. 112, U. S. Nat. Mus.*, p. 164, pl. 14, fig. 10.
1924 b. *Natica* (*Cryptonatica*) *aleutica*, OLDROYD, *Publ. Puget Sound Biol. Stat., Vol. 4*, p. 161, pl. 22, fig. 12.
1927. *Natica russa* GOULD, OLDROYD, *Stanf. Univ. Publ. Geol. Sci., Vol. 2, pt. 3*, p. 123.
1927. *Natica aleutica*, OLDROYD, *Ibid.* p. 123.
1931. *Natica russa*, GRANT and GALE, *Mem., San Diego Soc. Nat. Hist., Vol. 1*, pp. 798–799.

1939. *Natica* (*Cryptonatica*) *clausa tugaruana* NOMURA and HATAI, OTUKA, *Jour. Geol. Soc. Japan, Vol. 46, No. 544*, pp. 25, 30, pl. 2, text-figs. a–d.

1958. *Natica* (*Tectonatica*) *clausa tugaruana*, ITOIGAWA, *Mem. Coll. Sci., Kyoto Univ., Ser. B, Vol. 24, No. 4*, p. 261, pl. 2, fig. 5.

1958a. *Tectonatica russa*, HABE, *Publ. Akkeshi Biol. Stat., No. 8*, pp. 13–14, pl. 5, fig. 7.

Remarks: The specimens were found with calcareous operculums. *Natica russa* closely resembles *N. severa* GOULD; however, it can be distinguished from the latter by less inflated whorls and acuter apical angle. OTUKA's specimens, reported from the Hamada formation of the Shimokita Peninsula as *N. clausa tugaruana*, are quite similar to the present species. *Natica tugaruana* may be another species. Some of the specimens reported under the name of *Natica janthostoma* DESHAYES from certain localities of the "Omma-Manganji fauna" may correspond to *N. russa*.

The species is found in the Recent waters ranging from the Bering Sea to eastern Hokkaido, and to Catalina Island, Southern California.

Measurements (in mm):

Specimen:	Height	Height of body whorl	Length of aperture	Maximum diameter	Apical angle
CM 8526	24.0	21.3	18.5	22.2	107°
CM 8527	23.2	21.2	17.7	22.6	109
CM 8528	17±	16±	14±	15.1	105

Locality: Loc. 1 (rare); Loc. 2 (common); Loc. 3 (rare).

Family Cymatiidae

Genus *Fusitriton* COSSMANN 1903.

Fusitriton oregonensis (REDFIELD)

1848. *Fusus Oregonensis* SAY, REEVE, *Conch. Icon., Vol. 4, Fusus*, pl. 16, figs. 61 a, b.

1880. "*Triton* (*Priene*) *cancellatus* LAMARCK", TRYON, *Man. Conch., Vol. 3*, p. 34, pl. 16, figs. 164–167, pl. 17, figs. 170–172.

1927. *Argobuccinum* (*Fusitriton*) *oregonensis* (REDFIELD), OLDROYD, *Stanf. Univ. Publ. Geol. Sci., Vol. 2, pt. 2*, p. 242, pl. 37, figs. 1–3.

1931. *Fusitriton oregonensis*, KURODA in HOMMA, *Geology of Middle Shinano, Spec. Stud.*, p. 76, pl. 10, figs. 77, 78.

1931. *Ranella* (*Priene*) *oregonensis*, GRANT and GALE, *Mem. San Diego Soc. Nat. Hist., Vol. 1*, pp. 737–738, pl. 27, fig. 12.

1934. *Fusitriton oregonensis*, KINOSHITA and ISAHAYA, *Rep. Fish. Surv. Hokkaido Fish. Experim. Stat. No. 33*, p. 7, pl. 4, fig. 30.

1942. *Argobuccinum oregonensis*, WEAVER, *Univ. Washington Publ. Geol., Vol. 5*, pp. 418–419, pl. 83, fig. 15.

1954. *Argobuccinum oregonensis*, ABBOTT, *Amer. Seashells*, pp. 194–195, pl. 24, fig. g.

1958a. *Fusitriton oregonensis*, HABE, *Publ. Akkeshi Mar. Biol. Stat.*, No. 8, p. 16, pl. 2, fig. 8, pl. 5, fig. 21.

Locality: Loc. 2 (rare), Loc. 3 (common).

Family Muricidae

Genus *Trophonopsis* BUCQUAY, DAUTZENBERG and DOLLFUS 1882.

Trophonopsis aff. *beringi* (DALL)

Plate X, figures 11, 12.

1937. *Trophonopsis* (*Boreotrophon*) *beringi* (DALL), KANEHARA, *Trans. Proc. Pal. Soc.*

Japan, No. 8, (*Jour. Geol. Soc. Japan, Vol. 44*), p. 707, pl. 22, fig. 3.

Remarks: The present specimens resemble *Trophonopsis beringi* (DALL, 1902, p. 544) in the general outline, but they differ from the latter by lower spire, more distinct shoulder, shorter anterior canal and relatively larger aperture. *T. rotundus* (DALL) and *T. eucymata* (DALL) also resemble the present specimens but they have higher spires and longer canals. *T. subclavatus* (YOKOYAMA) has more spinose shoulder. *T. solitarius* (YOKOYAMA) has a similar outline, but the specimens can be distinguished by less number of varices.

"*T.* (*Boreotrophon*) *beringi*", reported by KANEHARA (1937) from the Pliocene of Teshio oil field, Hokkaido, may be identical with the present form.

The characters of the Japanese specimens are summarized as follows: Shell small for the genus, spire rather low, whorls about 5, angular but not spinose at the shoulder being at the middle part of the whorl: surface ornamented with low, triangular varices, 10 in number on the penultimate whorl, and with fine growth lines; spiral striations obsolete or none: body whorl large, about two thirds of the shell length; varices 12: aperture large, rounded oval in outline; canal not so long for the genus, slightly curved, semicircular in cross-section; basal fasciole weakly imbricated.

Measurements (*in mm*): Height 15.2, height of spire 4.5, long-diameter of aperture with canal 8.0, maximum diameter of body whorl 7.0. CM. 8529.

Locality: Loc. 1 (rare).

Trophonopsis sp.

Plate IX, figures 14, 15.

Remarks: Only one immature specimen is at hand. This is characterized by turretted spire, long and narrow canal, distinctly shouldered whorls. Varices are 16 on the body whorl.

Measurements (*in mm*): Height of shell 9.0, height of body whorl 6.4, length of aperture including canal 4.6, maximum diameter 4.0, apical angle 46°. CM. 8530.

Locality: Loc. 2 (rare).

Family Buccinidae

Genus *Neptunea* BOLTEN 1798.

Neptunea otukai CHINZEI, n. sp.

Plate IX, figures 12, 13.

Description: Shell medium for the genus, heavy and thick, fusiform, inflated but not strong; spire low, whorls more than 4, prominently shouldered; apex defective. Surface of the penultimate and the younger whorls ornamented with equally spaced 4 strong spiral cords, and fine growth lines; the third cord from the upper suture makes a distinct shoulder, and divides a whorl into lower vertical part and upper gently inclined part; first cord, which contacts the upper sture, low, broad and flat-topped. Interspaces of cords are broader than cords themselves and sculptured with 3 or sometimes 5 weak secondary threads, being more prominent in the middle of the interspace than other parts. The body whorl large, rounded, ornamented with 14 to 16 spiral cords which are spaced more densely

towards the base; secondary interstitial threads are 5 on the upper, diminish to 3 in the middle and to 1 on the basal parts of the body whorl. Aperture oval; both lips thinly encrusted, smooth; anterior canal large, broad, but not very long, slightly curved; basal fasciole thick and elevated.

Remarks: One well preserved specimen and many fragmental specimens are at the writer's disposal. The species are characterized by low spire, distinctly shouldered whorls and strongly raised four spiral cords.

The new species allies to *Neptunea uwasoensis* (OTUKA) (1935 c, p. 369–370, pl. 54, fig. 75) reported from the Pliocene Nozaki beds, one of the "Omma-Manganji" localities, of Oti graben of Toyama Prefecture. Judging from the resemblance of the spiral pattern, it may be presumed that the new one has some relation to *N. uwasoensis*, although it can be distinguished from the latter by much more inflated shell and less prominent shoulder. The new one closely resembles *N. yokoyamai* OYAMA (YOKOYAMA, "*Chrysodomus phoeniceus* DALL", 1920, p. 50–51, pl. 2, figs. 8–10), but the former differs from the latter in its pattern of spiral sculpture; i. e. *N. yokoyamai* has a prominent secondary and many weaker tertiary spiral threads. *N. andersoni* (MARTIN) (1914) also allies to the new species, but the shoulder of *andersoni* is much more prominent and situated nearer to the upper suture than the new one, and the ribs are much broader.

Measurements (in mm): Height 66, height of body whorl 54.4, maximum diameter 36.8, apical angle 62°. Holotype, CM 8531, Paratype, CM 8585, 8586.

Locality: Loc. 1 (common).

Genus *Coraeophos* MAKIYAMA 1936.

Type species: Phos (Coraeophos) meisensis MAKIYAMA, 1936 (original designation).

Remarks: MAKIYAMA established *Coraeophos* as a new subgenus of *Phos*. However, the ornamentation of *Phos* is composed essentially of strong axial sculptures, and spirals are only a subordinate character. On the other hand, the spirals of *Coraeophos* are prominent and stable as axials. Accordingly, the writer considers that they are of distinctly different two groups although some other important characters are common between them.

Coraeophos has many common characteristics with *Antillophos* (WOODRING, 1928) of Calibbean region, i. e. strongly cancellous sculpture, deep canal, well inflated columella with a strong fold, and outer lip with a shallow stromboid notch. The writer inclines to consider that there exists a close phylogenetic relation between *Coraeophos* and *Antillophos*. However, *Coraeophos* differs from *Antillophos* in having shorter canal and columella, equally strong (in most species of *Antillophos*, axial sculptures are more or less stronger and broader than radials) spiral cords and axial costae, and much shallower stromboid notch of the outer lip. In these respects, the writer hesitates to regard *Coraeophos* as a synonym of *Antillophos* and tentatively regards it as an independent genus.

The following species may be considered to belong to the genus *Coraeophos*:

Nassarius nakamurai KURODA (1931) . . . upper Miocene of Central Honshu.
Nassarius iwakianus (YOKOYAMA) (1931). . upper Miocene of Northeast Honshu.
Phos (Coraeophos) meisensis MAKIYAMA (1936) . . . upper Miocene of North Korea.

Coraeophos meisensis ninohensis CHINZEI n. subsp. . . . Pliocene of the present locality.

Tritiaria (*Antillophos*) *dumblei chehalisensis* (WEAVER) (ETHERINGTON, 1931; WEAVER, 1942) from the Astoria formation may belongs to the same genus judging from its short canal and cancellous sculpture. No definite *Antillophos* has hitherto been known from the northern Pacific region, and *Coraeophos* may be a circum-northern Pacific representative of "*Antillophos* group". The hitherto reported *Coraeophos* were restricted to the middle to upper Miocene only, and the present species is the first discovery from the Pliocene deposits.

Coraeophos meisensis ninohensis CHINZEI n. subsp.

Plate IX, figures 18–22.

Description: Shell medium size for the genus, turretted, thick; protoconch 2 whorls, small, surface eroded. Whorls 6 in number, moderately inflated, weakly shouldered; surface ornamented with cancellous sculpture. Body whorl large, about 3/5 of the shell height, moderately inflated and follows gradually to the base. Spiral cords 4 on the penultimate and the younger whorls, and 9 or 10 on the body whorl; equally prominent, equally spaced, flat, a little narrower than their interspaces, which become broad successively with growth; the uppermost cord forms a shoulder; weak interstitial spiral threads are seen on the penultimate and the body whorls. Axial costae 26 on the body whorl, 20 or 21 on the penultimate and 14 or 15 on the third whorls; equally prominent, flat, not united between whorls; costae of the body whorl become denser but weaker towards the aperture. Aperture oblique, fusiform, not large; outer lip thickened, a faint stromboid notch is near the anterior canal, inner margin distinctly crenulated, crenulations 10 in number; inner lip smooth, parietal callus thin, a slender indistinct fold is seen near the uppermost part of inner lip. Anterior canal short, deep, semicircular in section, turned backwards, abruptly truncated. Columella short, twisted, a low columellar fold is at the lowest; siphonal fasciole strongly inflated, sculptured by some spiral threads.

Remarks: Coraeophos meisensis (MAKIYAMA) (1936, p. 225, pl. 5, figs. 18, 19) was reported from the Miocene of Myŏnch'ŏn (Meisen), North Korea. The new subspecies closely resembles the type of *meisensis*, but differs in denser cancellous sculpture, i. e. axial costae of *meisensis* was described as 22 on the body whorl, while the present one has 26. The difference between *meisensis* and *ninohensis* is not so distinct as specific difference for the genus; hence, the writer regards *ninohensis* as a subspecies of *meisensis*, although both stratigraphical and geographical positions are separated.

"*Nassarius*" *iwakianus* (YOKOYAMA) and "*N.*" *nakamurai* KURODA may also belong to *Coraeophos* as stated before. "*N.*" *iwakianus* is distinguishable from *meisensis* in its higher spire, longer columella, less inflated whorls, more slender and less prominent sculptures, and also by less number of spiral cords (3 on earlier whorls and 8 on the body whorl). The type specimens of "*N.*" *nakamurai* are so fragmental that the differences can not precisely be recognized, but it may be distinguished from the present form by the number of spiral cords. "*N.*" *nakamurai* illustrated by KANNO and TOMIZAWA (1959, pl. 2, figs. 8, 9) has more slender and more highly turretted spire than any of other species of *Coraeophos*.

As stated in the discussion of the genus, the present new form is the youngest

in geological age of all known species of *Coraeophos*. It may be a relict of the upper Miocene species.

Measurements (in mm):

Specimen	Height	Height of body whorl	Maximum diameter	Length of aperture	Apical angle
Holotype CM 8532	23.7	15.0	11.5	11.8×4.4	46°
Paratype CM 8533	24.4	16.4	12.1	11.6×3.9	45°

Locality: Loc. 1 (common), Loc. 2 (rare).

Genus *Macron* H. ADAMS and A. ADAMS 1853.

"*Macron*" *nipponensis* CHINZEI, n. sp.

Plate IX, figures 10, 11.

Description: Shell moderate size for the genus, very thick and solid; spire acutely elevated, concave-conical, but not so high. Whorls 6 in number, moderately inflated, or flattish, not shouldered, separated by shallow but distinctly channeled sutures; body whorl large, about 3/4 of the shell height, rounded, lower half rather concave in outline. Surface ornamented with low broad spiral cords, and many weak spiral threads are visible on and between cords; cords 5 on the penultimate and the earlier whorls, the lowermost one sometimes covered by undulated suture of the lower whorl; cords about 13 on the body whorl, which become more distinct towards the base. Aperture not large, pentagonally ovate; broad and deep canal at the anterior; weakly notched at the posterior end. Outer lip very thick, weakly denticulated; dentition about 10; inner lip smooth with thin callus. Basal fasciole prominent; umbilical area shallowly perforated.

Remarks: This new species is characterized by its oval outline, very thick shell (4.5 mm thick at the aperture), weak dentition of the inner margin of the outer lip, and by the spiral cords which develop more distinctly towards the base. These characters agree well with the generic category of *Macron* (H. ADAMS and A. ADAMS, 1853; WENZ, 1943), a genus having limited distribution in the west coast of North America. However, as the form of spire and the general characters of spiral cords show neptuneid-type features, this species can easily be separated from the typical *Macron* and subgenus *Macroniscus* (THIELE, 1929). At a glance, this species seems to belong to *Neptunea*, but the above mentioned characters are not found in *Neptunea*.

The following species were hitherto recognized as *Macron*:—*M. aethiops* (REEVE), *M. aethiops* var. *kelletti* (A. ADAMS), *M. hartmanii* HERTLEIN and JORDAN, *M. lividus* (A. ADAMS), *M. merriami* ARNOLD, *M. orcutti* DALL and *M. trochlea* (GRAY). Among these species, *M. orcutti* DALL (1918, pp. 5, 6) most closely resembles the present species, but the latter can be easily distinguished from *orcutti* by having no sharp, distinct and strong grooves near the base of the body whorl, and by the weak dentitions of outer lip being only 10 in number.

Measurements (in mm): Height of shell 53.8, height of body whorl 44.0, diameter of body whorl 33.0, apical angle 70°. Holotype, CM 8534.

Locality: Loc. 2 (rare).

Genus *Mohnia* FRIELE 1878.

Mohnia sp.

Plate X, figures 19, 20.

Remarks: Two immature specimens are at hand. They have five or more whorls ornamented with strong, weakly curved axial varices (13 on the body whorl), and weak spiral threads. They resemble *M. yanamii* (YOKOYAMA) but are distinguishable from the latter by their more slender and smaller whorls. They also differ from *M. yanamii tenuis* HATAI and MISIYAMA in higher body whorl.

Measurements (in mm):

Specimen	Height	Height of body whorl	Maximum diameter
CM 8547	7.3	4.5	3.0
CM 8548	5.9	3.8	2.7

Locality: Loc. 1 (rare).

Family Cancellariidae

Genus *Admete* KYÖYER in MÖLLER 1842.

Admete lischkei (YOKOYAMA)

Plate X, figures 5-7.

1926a. *Cancellaria lischkei* YOKOYAMA, *Jour. Fac. Sci. Imp. Univ. Tokyo, Sec. 2, Vol. 1, pt. 8*, pp. 264–265, pl. 32, figs. 16, 17.

1927. *Cancellaria lischkei*, YOKOYAMA, *Jour. Fac. Sci. Imp. Univ. Tokyo, Sec. 2, Vol. 2, pt. 4*, p. 195, pl. 52, fig. 8 b.

Remarks: The species is characterized by axial ribs which become indistinct on the lower half of the body whorl, and by this character the species can easily be discriminated from "*Cancellaria*" *japonica* SMITH. *Admete cancellata* KOBELT can hardly be distinguished from this species.

Measurements (in mm):

Specimen	Height of shell	Maximum diameter	Height of body whorl	Apical angle
CM 8535	7.7	4.3	5.3	61°
CM 8536	8.5	4.6	6.0	59°

Locality: Loc. 2 (rare), Loc. 3 (rare).

Family Turridae

Genus *Suavodrillia* DALL 1918.

Suavodrillia oyamai CHINZEI, n. sp.

Plate IX, figures 1–5.

Description: Shell fairly large for the genus, thick, spire acuminated but not very high; whorls 6 in number, flat, strongly carinated near the lower

end; suture indistinct. Body whorl large, about two thirds of the shell height. Surface ornamented with strong spiral cords and flexuous growth lines. The body whorl, a strong, prominent, round-topped carina is at upper 1/3 to 1/4 of the whorl (including canal); a weak cord, occurring just at the deepest portion of the sinus, is situated between the carina and the upper suture; 4 to 6 spiral cords are below the carina, which become slender and less prominent towards the base with diminishing interspaces. The suture runs just at the first cord below the carina on the penultimate and the earlier whorls, hence the visible ornamentations are only the strongly shouldered carina situated at the lower 1/3 of the whorl and a weak upper cord. Aperture rather large, fusiform; inner lip smooth, columella columner, weakly twisted; outer lip excavated by deep sinus at the upper 1/6 of the aperture; canal short, shallow, curved backwards; basal fasciole inflated, imbricated.

Remarks: This new species is characterized by its lower and stout spire and by only 4 to 6 cords being situated below carina. *S. kennicottii* (DALL) is also a low spired form, but the new species is distinguished from *kennicottii* by the lower position of the carina (that of *kennicottii* is at about upper 1/5 to 1/6 of the body whorl, *oyamai* n. sp. is at about 1/3 to 1/4), and by less number of cords. *S. declivis* (V. MARTENS) has much more slender spire (apical angle of *declivis* is about 25°, *oyamai* is 35°), and has much number of cords near the base. *S. makiyamai* OTUKA and *S. yanagawaensis* NOMURA and ZINBO differ from this new one in size and ornamentation.

Measurements (in mm):

Specimen	Height	Height of body whorl	Maximum diameter	Length of aperture	Apical angle
Holotype CM 8537	20.8	13.3	9.0	8.8	34°
Paratype CM 8538	11.0+(13±)	8.9	6.0	6.3	34°
,, CM 8539	(body whorl broken)				35°

Locality: Loc. 1 (rare).

Genus *Antiplanes* DALL 1902.

Antiplanes (Rectiplanes) sadoensis (YOKOYAMA)

Plate IX, figures 6–9.

1926 a. *Pleurotoma sadoensis* YOKOYAMA, *Jour. Fac. Sci. Imp. Univ. Tokyo, Sec: 2, Vol. 1, pt. 8*, p. 259, pl. 32, fig. 3.

1937. *Antiplanes sadoensis*, NOMURA, *Saito Ho-on Kai Mus., Res. Bull., No. 13*, p. 174, pl. 24, figs. 5a, 5b.

1940 a. *Spirotropis (Antiplanes) sadoensis*, KANEHARA, *Bull. Imp. Geol. Surv. Japan, Vol. 27, No. 2*, p. 19, pl. 4, figs. 2a, 2b.

Remarks: The species was described by YOKOYAMA (1926 a) on the basis of a poorly preserved specimen which is now lost. The following short note can be added to YOKOYAMA's description:— Shell slender, solid, dextral, convex fuisform; whorls 8 to 10 in number, rathe flattish with round shoulder; surface

ornamented with many weak spiral striae which become wider with the growth of shell; protoconch consists of one whorl, simple and round, dextral; body whorl about 2/5 of the shell length; aperture narrow, outer lip with a deep and broad sinus near the upper end of the body whorl; canal moderately long, shallow and narrow, slightly convex against columella.

As already listed by GRANT and GALE (1931, p. 554), *A. sadoensis* resembles *A. thalaea* (DALL) from the west coast of North America in rounded whorl-outline, but the latter may be discriminated from the present species by more rounded whorls and higher spire. *A. sadoensis* figured by OTUKA (1949) may belong to the other species, judging from its lower spire and broader aperture. OZAKI (1958) illustrated a specimen as *A. sadoensis*, but this may also be separable from the typical *sadoensis* because of its flat whorls and shallow sutures.

A. sadoensis from the middle Miocene deposits of Uryu coal field (YOKOYAMA, 1932) is the oldest and an exceptional occurrence of *Antiplanes* in the Japanese Miocene. Most of fossil species of the genus (*A. perversa contraria* (YOKOYAMA), *A. obesus* OZAKI and *A. sadoensis*) are known in the Pliocene deposits, especially those of the Japan Sea side. *Antiplanes* is one of the most characteristic genera of the "Omma-Manganji fauna".

Measurements (in mm):

Specimen	Height	Maximum diameter	Height of body whorl	Number of whorl	Apical angles	Pleural angles
CM 8540	23.6	8.0	13.2	9.5	35°	17°
CM 8541	16.4	6.8	9.3	8	41	23°
CM 8542 a	20.9	7.6	11.8	9	40	28°
,, b	17.7	6.9	10.4	8	42	25
,, c	13.7	5.8	8.1	7.5	38	28
,, d	17.7	7.1	10.5	8	42	23

Locality: Loc. 1 (abundant), Loc. 2 (rare).

Genus *Propebela* IREDALE 1918.

Propebela cf. *nakamurai* (ONOYAMA)

Plate IX, figures 23–25.

cf. 1938. *Lora nakamurai* ONOYAMA, *Venus, Vol. 8, No. 2*, pp. 75, 80, fig. 2.

Remarks: The present specimen agrees well with ONOYAMA's description, although it has somewhat lower spire than the latter. The specimen has 13 prominent axial costae, has some definite and many faint spiral striations, and shallow but broad sinus near the posterior end of the aperture. As pointed out by ONOYAMA, *P. nakamurai* closely resembles *Lora pyramidalis* (STRÖM), a Recent species of circum-boreal seas; however, the former can be distinguished from the latter by coarser spiral striations and more prominent and curved axial costae.

Measurements (in mm): Height 15.6+(protoconch broken out), maximum diameter 6.6, height of body whorl 10.0, length of aperture with canal 7.1, apical angle 36°. CM 8543.

Locality: Loc. 1 (rare).

Propebela cf. *kurodai* (ONOYAMA)

Plate X, figures 17, 18.

cf. 1937. *Lora candida* YOKOYAMA, NOMURA, *Saito Ho-on Kai Mus., Res. Bull., No. 13*, p. 174, pl. 24, fig. 6.

cf. 1938. *Lora viridula kurodai* ONOYAMA, *Venus, Vol. 8, No. 2*, pp. 72, 79, fig. 3.

Remarks: This species is distinguishable from allied species, such as *P. turricula* (MONTAGUE), *P. candida* (YOKOYAMA), "*Lora*" *crosio* MAKIYAMA etc., by its smaller size, by duller apical angle, and by the ornamentation having 16 to 19 prominent axial ribs and may equally spaced spiral threads.

Measurements (in mm): Height 7.6, height of body whorl 4.7, maximum diameter 3.4, length of aperture including canal 3.2, apical angle 40°. CM 8544.

Locality: Loc. 1 (rare).

Propebela cf. *turricula* (MONTAGUE)

Plate X, figures 15, 16.

cf. 1846. *Pleurotoma rugulatus* REEVE, *Conch. Icon., Vol. 1, Pleurotoma*, pl. 37, fig. 345.

cf. 1884. *Bela turricula* MONTAGU, TRYON, *Man. Conch., Vol. 6*, p. 219, pl. 30, fig. 93; pl. 27, fig. 22; pl. 28, figs. 41, 44, 45; pl. 29, fig. 57; pl. 33, fig. 60.

cf. 1915. *Bela turricula* HARMER, *Plioc. Moll. Great Britain, Vol. 1, Pt. 2*, pp. 276–278, pl, 32, figs. 7–11.

cf. 1915. *Bela scalaris* (MÖLLER), HARMER, *Ibid.*, pp. 278–280, pl. 31, figs. 1, 4.

cf. 1915. *Bela rugulata* TROSCHEL, HARMER, *Ibid.*, pp. 282–283, pl. 31, figs. 5, 11.

cf. 1915. *Bela harpularia* var. *rosea* (LOVEN), HARMER, *Ibid.*, p. 288, pl. 32, figs. 16, 17.

cf. 1931. *Lora turricula*, GRANT and GALE, *Mem. San Diego Soc. Nat. Hist., Vol. 1*, pp. 515–517, pl. 32, figs. 42, 43.

cf. 1941. *Propebela turricula*, BARTSCH, *Proc. Biol. Soc. Washington*, p. 7, fig. 10.

cf. 1958. *Propebela turricula candida* (YOKOYAMA), ITOIGAWA, *Mem. Coll. Sci., Univ. Kyoto, Ser. B, Vol. 24, No. 4*, p. 254, pl. 2, fig. 19.

Remarks: Only one specimen is at hand. It is characterized by well inflated body whorl ornamented with 16 prominent axial ribs, and by many weak spiral cords. The specimen has fairly distinct shoulders and small body whorl. It is allied to "*Bela turricula*" and its synonyms illustrated by TRYON and HARMER and others.

The specimen resembles *Bela candida* YOKOYAMA (1926 a, pl. 34, fig. 1), but the latter has 21 axial ribs and very faint spiral threads. *Propebela kurodai* (ONOYAMA) has sharply angulated shoulders and stronger spiral ornamentation.

Measurements (in mm): Height of shell 11.1, height of body whorl 6.7, length of aperture including canal 4.4, maximum diameter 5.0, apical angle 41°. CM 8545.

Locality: Loc. 1 (rare).

Propebela sp.

Plate IX, figures 16, 17.

cf. 1942. *Lora tabulata* (CARPENTER), WEAVER, *Univ. Wash. Publ. Geol., Vol. 5*, pp. 519–520, pl. 97, fig. 12.

Remarks: The general outline of the specimen agrees with that of *Bela candida* YOKOYAMA; however, this is distinguishable from *candida* by many distinct spiral cords separated by narrower interspaces, and by much more inflated body whorl. The present specimen is identical with *Lora tabulata* of WEAVER (1942), which does not agree with description and figures of CARPENTER's original specimens (PALMER, 1958, pp. 234–235, pl. 25, figs. 7–11). Because of the scanty knowledge on the general characters of *Lora tabulata*, the writer hesitates to name the present specimen *tabulata*.

Measurements (in mm): Height of shell 13.2, height of body whorl 9.0, length of aperture including canal 6.7, maximum diameter 6.4, apical angle 48°. CM 8546.

Locality: Loc. 1 (rare).

Family Pyramidellidae

Genus *Menestho* MÖLLER 1842.

Menestho araii (OTUKA)

Plate X, figures 23–25.

1938. *Odostomia (Evalea) araii* OTUKA, *Jour. Geol. Soc. Japan, Vol. 46, No. 544*, p. 29, pl. 2, figs. 13, 14.

Remarks: OTUKA described *araii* on the basis of a single specimen. Some noticeable variation in sculptures is seen among the specimens collected at Loc. 1. The following short notes can be added to OTUKA's description. Shell small, elongate conical; number of whorls 4 and a half in general, 6 at the maximum; sutures deeply channeled; protoconch one and a half. Whorls not shouldered, gently inflated; ornamented by equally spaced, narrow but well marked spiral grooves, 4 or 5 in number on the penultimate and the younger whorls; and also ornamented by fine, nearly straight growth lines. Body whorl large, about 2/5 of the shell height, ornamented by equally spaced, 5 or 6 spiral grooves situated between periphery and the upper suture. Columella short, weakly curved; umbilical part shallowly depressed, parietal lip covered by thin callus. Columellar fold not seen.

Menestho araii is quite similar to *Odostomia (M.) fetella* DALL and BARTSCH, a southern Californian species, in shell outline and sculpture of the younger whorls. However, the latter differes from *M. araii* in having many spiral grooves below the periphery of the body whorl.

Measurements (in mm):

Specimen	Height	Maximum diameter	Height of body whorl	Length of aperture	Apical angle	Number of whorls
CM 8549	4.9	2.3	2.6	1.6	30°	6
CM 8550	3.3	1.7	2.1	1.3	—	4.5
CM 8551	3.6	1.7	2.0	1.3	31°	4.5
CM 8552	3.2	1.8	2.1	1.3	—	4.5
CM 8553	2.8	1.6	1.9	1.1	—	4
CM 8554	2.6	1.5	1.8	1.1	—	3.5
Holotype (OTUKA's No. 4269)	3.9	2.0	2.4	1.7	—	4

Locality: Loc. 1 (common).

Menestho iwatensis CHINZEI, n. sp.

Plate X, figures 21, 22.

Description: Shell small, elongate-conical; protoconch one and a half whorls, small, helicoid, surface smooth, extreme end depressed. Whorls 3 and a half in number, fairly inflated, suture channeled; whorl-surface ornamented with narrow, distinct spiral grooves and with fine growth lines. Spiral grooves equally spaced and equally prominent, 7 in number on the penultimate whorl, 5 on the third and the younger whorls; the uppermost groove situated close to the suture, and second groove is split into two shallower grooves. Body whorl large, 2/3 of the shell height, gently inflated; periphery is at the middle portion of the whorl; spiral grooves 16, equally spaced but somewhat closer near the umbilical region. Aperture oval, posterior end acute; anterior end rounded, turned outwards; outer lip smooth; columella short, curved, with a low broad columellar fold. Umbilicus depressed, covered by thin callus.

Remarks: The new species is characterized by moderately inflated and large body whorl, equally spaced, equally prominent 16 spiral grooves, and by large oval aperture with a low columellar fold. Although the surface ornamentation of *iwatensis* n. sp. is similar to that of *Odostomia* (*Menestho*) *pharcida* DALL and BARTSCH, the former can be easily discriminated from the latter by its lower spire, more inflated whorls and much larger body whorl. *M.* (*Oscilla*) *yokohamensis* NOMURA closely resembles the new species but they differ in spiral sculpture, i. e. *M. yokohamensis* has broad, rounded cords and the new species has narrow grooves. *M. sexulcata* NOMURA and *M. s-hataii* NOMURA have also similar ornamentation, but they differ from the present new species in their higher spire and smaller body whorl.

Measurements (in mm): Height of shell 3.3, height of body whorl 2.2, length of aperture 1.5, width of aperture 1.0, maximum diameter 1.7. Holotype, CM 8555.

Locality: Loc. 1 (rare).

Menestho nomurai CHINZEI, n. sp.

Plate X, figures 9, 10.

Description: Shell large for the genus, elongate conical, spire rather low; protoconch small, one and a half whorls, surface smooth, extreme end depressed. Whorls 4 and a half; suture very distinct and grooved; each whorl strongly shouldered near the upper suture, shelf narrow, flat, nearly horizontal. Surface ornamented by well marked, subequally spaced, narrow spiral grooves, and fine weakly convex growth lines; number of spiral grooves is 6 on the younger whorls, the uppermost of which is split into two shallower grooves on the penultimate and body whorls. Body whorl large, moderately inflated, ornamented with 12 or 13 equally spaced spiral grooves, which successively weaken to the base; basal part (around the umbilicus) ornamented by faint spiral threads and growth lines. Aperture large, oval; anterior end rounded, bent outwards; posterior end acute; columella short, curved; umbilicus channeled. Columellar fold one, low and broad ridge-shaped.

Remarks: The only one specimen is at the writer's disposal. It is characte-

rized by distinctly shouldered whorls. Such a species of *Menestho* having horizontal shoulders has not been known in the circum-Pacific region. The new species resembles *M. kesennumensis* NOMURA in having distinct shoulders, but the shoulders of the latter are not so prominent and inclined outwardly; moreover, it can be distinguished easily from the latter by its lower spire and much larger body whorl. The new species closely resembles *Odostomia turricula* DALL and BARTSCH in having peculiar flat shoulders. However, *O. turricula* differs from the new one in having prominent axial sculpture.

Measurements (in mm): Height of shell 4.8, height of body whorl 3.1, aperture 2.0×1.1, maximum diameter 2.9, apical angle 44°. Holotype, CM 8556.

Locality: Loc. 2 (rare).

Genus *Odostomia* FLEMING 1813.

Odostomia (Evalea) cf. *aleutica* DALL and BARTSCH

Plate XI, figures 4, 5.

cf. 1909. *Odostomia (Evalea) aleutica* DALL and BARTSCH, *Bull. 68, U. S. Nat. Mus.*, p. 196, pl. 22, fig. 5.

Remarks: Only one specimen was collected. It is characterized by well inflated large body whorl and by shell surface being ornamented by fine growth lines and many very faint spiral threads. No distinct columellar fold is visible. Among the known Japanese species, *Odostomia* (s. s.) *makiyamai* NOMURA, reported from Shiogama Bay, is the closest to this species, but is distinguishable from *aleutica* by smaller body whorl, more rounded aperture and by a prominent columellar fold.

O. aleutica was reported from Iliuliuk Harbor, Alaska (at a depth of 55 fm. with bottom temperature of 41° 6 F), and from Captains Harbor (at 25 fm. on muddy bottom).

Measurements (in mm): Height of shell 2.8, height of body whorl 1.8, length of aperture 1.2, maximum diameter 1.6, apical angle 41°. CM 8557.

Locality: Loc. 1 (rare).

Family Glycymeridae

Genus *Glycymeris* DA COSTA 1778.

Glycymeris derelicta (YOKOYAMA)

Plate XI, figures 12–15.

1928. *Pectunculus derelictus* YOKOYAMA, *Jour. Fac. Sci. Imp. Univ. Tokyo, Sec. 2, Vol. 2, pt. 7*, p. 361, pl. 69, fig. 1.

1935. *Glycymeris direlicta*, NOMURA and ZINBO, *Saito Ho-on Kai Mus., Res. Bull., No. 6*, pp. 157–158, pl. 15, figs. 1, 2.

Remarks: The specimens have very characteristic features, such as, unequilateral outline, opisthogyral beak, assymmetric sculptures of ligamental area, and acute apical angle. As compared with YOKOYAMA's type, some of the present specimens have more round and others are more unequilateral shell, and radial rib-like striae of present specimens seem to be denser than that of YOKOYAMA's specimen. *G. derelicta*, reported from the Miocene Yanagawa formation by NOMURA and ZINBO, has more rounded dorsal margin than both YOKOYAMA's and

the present specimens, although it may safely be said that they fall within an intraspecific variation.

The characteristics of the present specimens are as follows: Shell medium size for the genus, thick, rounded or subrounded, equivalve but inequilateral, height equal to or little higher than length; anterior margin broadly rounded; posterior margin rounded or somewhat protruded near the posterior muscular scar. Beak situated about middle portion of the shell, small, prominent, not touching, slightly turned backwards; apical angle about 90° to 110°. Surface ornamented with many faint broad rib-like striae, on which weaker secondary radiating lines are seen, and with many werk concentric growth lines; radiating sculptures appear to be obsolate on both sides of shell. Hinge plate heavy, broad, flattish, strongly arcuated; ligamental area triangular, short, about 1/3 to 1/4 of the shell length, anterior half longer than posterior, sculptured with distinct but asymmetrical chevron grooves, extreme point of inverted-V-shape of grooves dislocated to posterior from just below the beak; 20 to 30 oblique, lameller teeth which become weak and irregular at the middle. Adductor muscular scar distinct, anterior scar more or less larger and elongated.

G. nipponica (Yokoyama) is an allied species. However, this is distinguishable from *G. derelicta* by its smaller size, lower shell and narrower ligamental area. One of its cotype illustrated by Yokoyama (1920, pl. 18, figs. 7a, 7b) has an outline somewhat similar to the present form. *G. septentrionalis* (Middendorf) resembles *derelicta* in its subangular outline and opisthogyral beak, but the former is distinguishable from the latter by its lower shell.

A specimen collected by Otuka from the Omma formation of Ishikawa Prefecture and is now in the collection of our Institute may be identical with this species. The type of Yokoyama was reported from the Pliocene of Higashiyama oil field, Niigata Prefecture. The species may be a common constituent of the "Omma-Manganji fauna".

Measurements (in mm):

Specimen	Valve	Length	Height	Thickness	Number of chevron grooves	Number of anterior teeth	Number of posterior teeth	Number of marginal crenulation
GM 8558	(R-L)	34.4	37.0	10.6×2	11	10	13	28
GM 8560	(L)	39.1	40.2	11.9	10	14	10	?
GM 8561	(R)	32.5	34.3	9.5	8	14	12	25
GM 8559	(L)	33.0	32.9	9.0	7	14	17	22
GM 8562	(R)	40.0	39.1	9.7	7	11	13	22

Locality: Loc. 1 (common), Loc. 2 (rare), Loc. 3 (rare).

Family Limopsidae

Genus *Nucinella* S. Wood 1851.

Nucinella (Huxleyia) ochiaiensis Chinzei, n. sp.

Plate XI, figures 1–3.

Description: Shell small, oval, strongly inflated, equivalve; umbo low, rounded and small; surface almost smooth, sculptured only by faint growth lines. Anterior margin broadly rounded; postero-dorsal margin weakly shouldered near the end of "cardinal" hinge plate, postero-ventral margin gently arcuated; vent-

ral end somewhat produced, rounded. Hinge area broad, composed of a large, subtrigonally depressed ligamental area being situated just below the umbo; five, thick, tabular or tuberculous teeth situated at the posterior of the ligamental area and separated by deep sockets; and a large, prominent, posterior lateral tooth is seen near the middle of the posterior margin. Internal surface smooth; muscular impressions large, but weak; inner margin smooth, edged.

Remarks: Nucinella (*Huxleyia*) *sulcata* (A. ADAMS) resembles the new species; however, the new one can be distinguished by smaller shell, more rounded oval outline, strong posterior lateral tooth, and almost smooth surface. *N.* (*Huxleyia*) *munita* (DALL) is closely allied to the new one, and they can hardly be distinguishable unless by shell outlines, i. e. the present new one has more elongated shell and more produced ventral end.

Measurements (*in mm*):

Specimen	Valve	Length	Height	Thickness	Length of hinge plate
Holotype CM 8566	L	2.1	2.5	0.9	1.1
Paratype CM 8567	R	1.9	2.3	0.8	1.0
〃 CM 8568	〃	1.5	1.7	0.6	0.7

Locality: Loc. 1 (rare).

Family Mytilidae

Genus *Crenella* BROWN 1827.

Crenella yokoyamai NOMURA

1922. *Crenella divaricata* YOKOYAMA, *Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 44*, p. 175, pl. 15, figs. 10, 11.

1932. *Crenella yokoyamai* NOMURA, *Sci. Rep. Tohoku Imp. Univ., Vol. 15, No. 2*, p. 74.

Remarks: The specimen has very rounded outline and irregularly bifurcated radial ornamentation. Bifurcation of sculpture is the character common between *C. yokoyamai* and *C. nisigotoensis* NOMURA and HATAI. Although the writer could not find out the difference between the two species, he tentatively accepts the opinion of NOMURA and HATAI (1936) and regards the above two as different species, because he was unable to examine the type specimen of *C. nisigotoensis*.

Measurements (*in mm*): Length 2.2, height 2.5, thickness 0.9.

Locality: Loc. 1 (rare).

Family Carditidae

Genus *Venericardia* LAMARCK 1801.

Venericardia ferruginea ochiaiensis CHINZEI

Plate XI, figures 6, 7.

1958 a. *Venericardia ochiaiensis* CHINZEI, *Venus, Vol. 20, No. 1*, pp. 120–125, pl. 7, figs. 1, 2, 4, 5, 7–14.

Remarks: This is a most abundant species among those discovered at the studied localities. The writer (1958 a) once recognized it as an independent species on the basis of their characters, such as thick shell and 17 to 19 granulated strong ribs. However, the strong granulations may be a result of abnormal

thickening of shell; accordingly, the differences between *V. ferruginea* (CLESSIN) and *ochiaiensis* lie merely in the shell outline and the number of ribs. Hence, the writer considers that they may belong to the same species *ferruginea* differing only in their subspecific positions. CM 8501—8512.

Family Lucinidae

Genus *Lucinoma* DALL 1901.

Lucinoma acutilineatum (CONRAD)

1849. *Lucina acutilineata* CONRAD, *U. S. Expl. Exped., Vol. 10, Geol.*, p. 725.
1909. *Phacoides acutilineatus*, DALL, *U. S. Geol. Surv., Prof. Pap., No. 59*, pp. 116–117, pl. 12, fig. 6.
1923. *Lucina borealis* LINNÉ, YOKOYAMA, *Japan. Jour. Geol. Geogr., Vol. 2, No. 3*, p. 57, pl. 6, fig. 11.
1931. *Phacoides (Lucinoma) acutilineatus*, ETHERINGTON, *Univ. Calif. Publ., Geol. Sci., Vol. 20, No. 4*, pp. 76–77, pl. 4, fig. 5.
1931. *Lucina (Myrtea) acutilineata*, GRANT and GALE, *Mem. San Diego Soc. Nat. Hist., Vol. 1*, pp. 286–287, pl. 14, figs. 22 a, 22 b.
1935 a. *Lucina (Myrtea) acutilineata*, NOMURA and HATAI, *Saito Ho-on Kai Mus., Res. Bull., No. 5*, p. 9, pl. 2, figs. 3, 4.
1938. *Lucina acutilineata*, NOMURA, *Sci. Rep. Tohoku Imp. Univ., 2 Ser., Vol. 19, No. 2*, p. 253, pl. 35, fig. 5.
1940. *Lucina acutilineata*, NOMURA and ONISHI, *Japan. Jour. Geol. Geogr., Vol. 17, Nos. 3, 4*, p. 182, pl. 17, figs. 9–12.
1942. *Lucina acutilineata*, WEAVER, *Univ. Wash. Publ. Geol., Vol. 5, pt. 1*, pp. 143–144, pl. 34, figs. 8, 11, 16.
1955. *Lucinoma acutilineata*, ITOIGAWA, *Mem. Coll. Sci., Univ. Kyoto, Ser. B, Vol. 22, No. 2*, p. 129, pl. 6, fig. 4.
1958. *Lucinoma acutilineata*, OZAKI, *Bull. Nat. Sci. Mus., Vol. 4, No. 1*, p. 125, pl. 18, figs. 11, 12; pl. 21, fig. 3; pl. 23, fig. 4.

Remarks: Many well preserved large specimens are found. According to K. OYAMA's information, *L. acutilineatum* now inhabits the lower continental shelf of muddy bottom. *L. annulatum* (REEVE) and *L. concentrica* (YOKOYAMA) are shallow water forms. *L. acutilineatum* has lower shell than the latter two. CM 8569—8571.

Locality: Loc. 1 (common), Loc. 2 and 3 (rare).

Family Cardiidae

Genus *Clinocardium* KEEN 1936.

Clinocardium iwatense CHINZEI, n. sp.

Plate XI, figures 9, 10.

Description: Shell rather large, thick, strongly inflated, inequilateral; obliquely rounded-oval or "fan-shaped" in outline, with length larger than height. Anterior part large, antero-dorsal margin not shouldered, rounded, gently arcuated and gradually continues to the ventral margin. Postero-dorsal margin weakly curved; ventral margin broadly arched, long, extending to prolonged posterior end. Posterior end protruded and forms nearly a right angle. Beak large, prominent, situated nearly in the middle or somewhat anterior portion of shell, turned inwardly and prosogyrally; ligamental area deeply excavated. Hinge thick and strong, having a pair of cyclodont cardinal teeth and long and deep lateral teeth. Surface ornamented with 30 to 32, two sided and sharply edged

radial ribs, being regularly imbricated by many concentric growth lines, some growth periods are well marked on the dorsal half of the shell surface; rib-interspaces shallow and rounded, also wrinkled by growth lines. Angle of antero- and postero-dorsal margins at the beak about 105° to 110°. Inner margin crenulated.

Remarks: This new species is characterized by large and thick shell, protruded posterior end, and sharply edged triangular radial ribs. Fossil and recent species of *Clinocardium* characterized by distinct triangular ribs, reported from the adjacent areas of Japan are *C. ciliatum* (FABRICIUS), *C. shinjiense* (YOKOYAMA), *C. uyemurai* (KANEHARA), *C. yamasakii* (MAKIYAMA), and *C. chikagawaense* KOTAKA. The present new species resembles *C. ciliatum* and *C. chikagawaense* in many respects, but can be discriminated from the latter two by the outline of shell and number of radial ribs. Both *C. ciliatum* and *chikagawaense* have oval outlines and 35 or 36 radial ribs. *C. chikagawaense* KOTAKA (1950) was reported from the Pliocene Hamada formation of the Shimokita Peninsula, Aomori Prefecture. The writer could not find out any distinct differences between *C. ciliatum* and *chikagawaense*, so he considers the latter as a subspecific or merely a synonymous form of *ciliatum*.

Measurements (in mm): Length 71.8, height 60.5, thickness 33. Holotype, CM 8572, Paratype, CM 8573, 8574.

Locality: Loc. 2 (common).

Genus *Serripes* GOULD 1841.

Serripes sp. cf. *notabilis* (SOWERBY)

cf. 1915. *Cardium (Serripes) notabilis* SOWERBY, *Ann. Mag. Nat. Hist., Ser. 8, Vol. 16*, p. 169, pl. 10, fig. 9.

cf. 1935 a. *Serripes notabilis*, OTUKA, *Trans. Proc. Pal. Soc. Japan, No. 2 (Jour. Geol. Soc. Japan, Vol. 42, No. 504)*, p. 602, pl. 1, figs. 9, 10.

Remarks: Although the specimen examined is broken, it may be referred to *S. notabilis*, judging from the feature of hinge tooth and surface ornamentation. *S. makiyamai* (YOKOYAMA) (1928), once considered by OTUKA (1935) as a synonmym of *notabilis*, is a species distinctly different from the latter. CM 8575.

Family Tellinidae

Genus *Macoma* LEACH 1819.

Macoma calcarea (GMELIN)

Plate XI, figure 11, text-figure 3-1.

1791. *Tellina calcarea* GMELIN, *Syst. Nat. ed. 13, Vol. 1, pt. 6*, p. 3236.

1791. *Tellina lata* GMELIN, *Ibid.*, p. 3237.

1851. *Tellina lata*, MIDDENDORFF, *Sibil. Reise, 2 Bd., Thl. Moll.*, pp. 257–258, Taf. 23, figs. 1–5.

1871. *Tellina calcarea*, RÖMER, *Conch. Cab., Bd. 10, Ab. 4*, pp. 222–224, Taf.43, figs. 1–6.

1867. *Tellina calcarea*, REEVE, *Conch. Icon., Vol. 17, Tellina*, pl. 28, fig. 151.

1909. *Macoma calcarea*, DALL, *U. S. Geol. Surv., Prof. Pap., No. 59*, pp. 126–127, pl. 14, fig. 8.

1924 a. *Macoma calcarea*, OLDROYD, *Stanf. Univ. Publ., Univ. Ser. Geol. Sci., Vol. 1, No. 1*, pp. 173–174, pl. 42, fig. 5.

1931. *Macoma calcarea*, GRANT and GALE, *Mem. San Diego Soc. Nat. Hist., Vol. 1*, pp. 369–370.

1934. *Macoma calcarea*, NIINO, *Jour. Geol. Soc. Tokyo, Vol. 41, No. 487*, p. 181, pl. 6, figs. 17, 18.
1935. *Macoma calcarea*, OINOMIKADO and IKEBE, *Venus, Vol. 5, No. 1*, pp. 14–17, figs. 1–6.
1935. *Macoma calcarea*, NOMURA, *Saito Ho-on Kai Mus., Res. Bull., No. 5*, p. 116, pl. 6, figs. 5, 6.
cf. 1939. *Macoma praetexta oinomikadoi* OTUKA, *Jour. Geol. Soc. Japan, Vol. 46, No. 545*, p. 28, pl. 2, figs. 15–18.
1942. *Macoma calcarea*, WEAVER, *Univ. Wash. Publ. Geol., Vol. 5, Pt. 1*, pp. 212–213, pl. 49, fig. 11.
1958 a. *Macoma calcarea*, HABE, *Publ. Akkeshi Mar. Biol. Stat., No. 4*, p. 18, pl. 1, figs. 14, 15.

Remarks: The specimens at hand are peculiar in shape because of the strongly compressed shell, straight antero- and postero-dorsal margin, and the beak being situated near the posterior end. The summarized characters of the specimens are as follows: shell medium size, thin, much compressed; left valve more convex than the right; posterior end slightly twisted to the right; beak situated at the posterior 1/3 of the shell; antero-dorsal margin nearly straight, and curving gently towards the ventral margin; postero-dorsal margin almost straight or weakly convex; posterior end turns sharply; ventral margin gently arcuated sub-parallel to the antero-dorsal margin and continues to a semicircular anterior end; growth lines imbricated near the postero-dorsal margin; pallial sinus not large, rounded rhomboidal, with a longer diameter about 2/5 of the

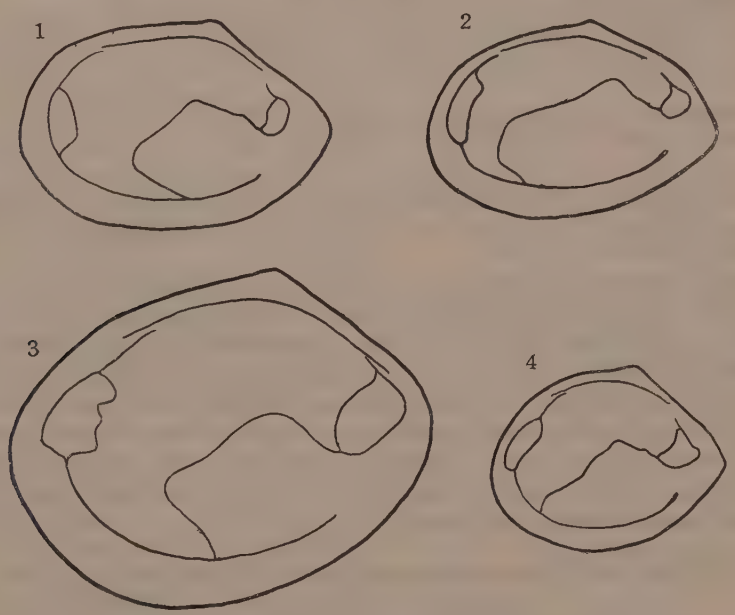


Figure 3. Internal sculpture of *Macoma calcarea* (GMELIN) and its allies showing the shape of pallial sinus. (natural size)
1. *Macoma calcarea* (GMELIN) . . . Pliocene (Kubo formation, present locality)
2. *Macoma praetexta* (V. MARTENS) . . . Recent (Sagami Bay)
3. "*Macoma praetexta oinomikadoi* OTUKA" . . . Pliocene (Hamada formation, type specimen).
4. *Macoma incongrua* (V. MARTENS) . . . Recent (Sagami Bay)

shell length, and joins the pallial line near the middle portion of the shell.

The specimens closely resemble *M. calcarea* of WEAVER (1942) and of RÖMER (1871). *M. calcarea* can be discriminated from *M. incongrua* (v. MARTENS), *M. tokyoensis* MAKIYAMA, *Tellina candida* (LAMARCK) by the form of pallial sinus, and from *M. arctata* (CONRAD) by the outline of shell.

Macoma praetexta oinomikadoi OTUKA (1939), reported from the upper Pliocene Hamada formation of the Shimokita Peninsula, may be referred to *calcarea* considering its shell outline and the feature of pallial impression.

Measurements (in mm):

Specimen	Valve	Length	Height	Thickness	Apical angle
GM 8576	(R-L)	44.7	31.6	11.5	120°
GM 8577	(R)	19.0	13.6	3.4	115°
GM 8578	(R-L)	39.2	28.0	9.2	

Locality: Loc. 2 (rare), Loc. 3 (rare).

Family Hiatellidae

Genus *Panomya* GRAY 1857.

Panomya ampla DALL

Plate XI, figure 8.

1898. *Panomya ampla* DALL, *Trans. Wagner Inst. Sci., Vol. 3*, p. 833.
1902. *Panomya ampla*, DALL, *Proc. U. S. Nat. Mus., Vol. 24*, p. 560, pl. 40, figs. 3, 4.
1916. *Panomya arktica* var. *turgida* DALL, *Proc. U. S. Nat. Mus., Vol. 24*, p. 416, pl. 2, fig. 1.
1921. *Panomya turgida*, DALL, *Bull. U. S. Nat. Mus., No. 112*, p. 54, pl. 2, fig. 1.
1924a. *Panomya ampla*, OLDROYD, *Stanf. Univ. Publ. Geol., Vol. 1, No. 1*, p. 207, pl. 10, fig. 3.
1924b. *Panomya ampla*, OLDROYD, *Puget Sound Biol. Stat., Vol. 4*, pp. 63–64, pl. 6, fig. 3.
1931. *Panomya ampla*, GRANT and GALE, *Mem. San Diego Soc. Nat. Hist., Vol. 1*, pp. 426–427, pl. 21, figs. 10 a, 10 b.
1952. *Panomya turgida*, HABE, *Gen. Japan. Shells, No. 3*, p. 233, figs. 606, 607.
1955. *Panomya ampla*, HABE, *Publ. Akkeshi Mar. Biol. Stat., No. 4*, p. 21, pl. 5, figs. 3, 4.

Remarks: As already stated by others, *P. ampla* and *P. turgida* may be merely intraspecific varieties. The present specimens are probably identical with *P. ampla* described by GRANT and GALE (1931), and also closely resemble *P. turgida* of DALL (1916). This species is common in cold waters of Northeast Japan, especially in the Pacific side. *Panomya* contained in the Miocene deposits of Northeast Japan is known as *P. simotomensis* OTUKA, and the present localities may be the lowest horizon of *P. ampla*.

Measurements (in mm):

Specimen	Length	Height	Thickness (conjoined valve)
GM 8580	76.1	ca. 52	ca. 32
GM 8581	ca. 91	ca. 51	ca. 37
GM 8582	?	ca. 36	ca. 21

Locality: Loc. 1 (common), Loc. 2 (rare).

Family Pandoridae

Genus *Pandora* CHEMNITZ 1795.

"*Pandora*" sp., cf. *pulchella* YOKOYAMA

cf. 1926 b. *Pandora pulchella* YOKOYAMA, *Jour. Fac. Sci. Imp. Univ. Tokyo, Vol. 1, pt. 9*, p. 381, pl. 45, fig. 4.

cf. 1931. *Pandora pulchella*, KURODA in HOMMA, *Geology of Middle Shinano, Spec. Stud.*, p. 44, pl. 4, fig. 19.

cf. 1936. *Pandora pulchella*, OTUKA, *Trans. Proc. Pal. Soc. Japan, No. 4 (Jour. Geol. Soc. Japan, Vol. 43, No. 516)*, p. 732, pl.42, fig. 10.

cf. 1958 b. *Heteroclidus pulchellus*, HABE, *Publ. Seto Mar. Biol. Labor., Vol. 6, No. 3*, p. 273, pl. 8, fig. 26.

Remarks: The present form resembles *Pandora pulchella*, but differs from the typical *pulchella* in less concave postero-dorsal margin. However, because of poor preservation of the specimens, the specific position cannot be determined precisely. CM 8584.

Locality: Loc. 1 (common), Loc. 2 (rare), Loc. 3 (rare).

References

ABBOTT, R. T., 1954, American Seashells: *Van Nostrand C. Inc.* pp. 1–541, pls. 40.

ADAMS, H. & ADAMS, A., 1853, The Genera of Recent Mollusca: *Vols. 1–3.*

BARTSCH, P., 1911, The Recent and Fossil Mollusks of the Genus *Alvania* from the West Coast of America: *Proc. U. S. Nat. Mus., Vol. 41*, pp. 333–362, pls. 29–32.

———, 1941, The Nomenclatorial Status of Certain Northern Turritid Mollusks: *Proc. Biol. Soc. Washington, Vol. 54*, pp. 1–14, pl. 1.

CHINZEI, K., 1958 a, A New Pliocene *Venericardia* from the Northern End of Iwate Prefecture, Japan: *The Venus, Vol. 20, No. 1*, pp. 119–128, pl. 7.

———, 1958 b, Pliocene Stratigraphy of the Northern End of the Kitakami Mountains, Northeastern Japan: *Jour. Geol. Soc. Japan, Vol. 64, No. 757*, pp. 526–536.

CONRAD, T. A., 1849, Fossils from the Northwestern America: Mollusca: *U. S. Expl. Exped., Vol. 10 (Geol.), App. 1*, pp. 723–729.

DALL, W. H., 1898, Contributions to the Tertiary Fauna of Florida. Part 4: *Trans. Wagner Free Inst. Sci., Philad., Vol. 3, Pt. 4*, pp. 571–947, pls. 23–35.

———, 1902, Illustrations and Descriptions of New, Unfigured, or Imperfectly Known Shells: *Proc. U. S. Nat. Mus., Vol. 24, No. 1264*, pp. 499–566, pls. 27–40.

———, 1909, Contributions to the Tertiary Paleontology of the Pacific Coast: I. The Miocene of Astoria and Coos Bay, Oregon: *U. S. Geol. Surv. Prof. Pap. No. 59*, pp. 5–278, pls. 1–23.

———, 1916, Diagnosis of New Species of Marine Bivalve Mollusks from the Northwest Coast of America in the Collection of the United States National Museum: *Proc. U. S. Nat. Mus., Vol. 52*, pp. 397–417.

———, 1918, Description of New Species of Shells Chiefly from Magdalena Bay, Lower California; *Proc. Biol. Soc. Washington, Vol. 31*, pp. 5–8.

———, 1919 a, Descriptions of New Species of Mollusks of the Family Turritidae from the West Coast of America and Adjacent Regions: *Proc. U. S. Nat. Mus., Vol. 56*, pp. 1–86, pls. 1–24.

———, 1919 b, Descriptions of New Species of Mollusca from the North Pacific Ocean in the Collection of the United States National Museum: *Proc. U. S. Nat. Mus., Vol. 56*, pp. 293–371.

———, 1921, Summary of the Marine Shell bearing Mollusks of the Northwest Coast of America: *Bull., U. S. Nat. Mus., 112*, pp. 1–215, pls. 1–22.

———, and BARTSCH, P., 1906, Notes on Japanese, Indopacific, and American Pyramidellidae: *Proc. U. S. Nat. Mus., Vol. 30*, pp. 321–369, pls. 17–26.

ETHERINGTON, T. J., 1931, Stratigraphy and Fauna of the Astoria Miocene of Southwest Washington: *Univ. Calif. Publ. Geol. Sci., Vol. 20, No. 4*, pp. 31–142, pls. 1–14.

GMELIN, J. F., 1791, Systema Naturae, Ed. 13: *Vol. 1, pt. 6*.

GRANT IV, U. S. and GALE, H. R., 1931, Catalogue of the Marine Pliocene and Pleistocene Mollusca from California and Adjacent Regions: *Mem. San Diego Soc. Nat. Hist., Vol. 1*, pp. 7–1036, pls. 1–32.

HABE, T., 1952, Genera of Japanese Shells (Pelecypoda and Scaphopoda): pp. 1–326.

———, 1955, Fauna of Akkeshi Bay, No. 21. Pelecypoda and Scaphopoda: *Publ. Akkeshi Mar. Biol. Stat., No. 4*, pp. 1–31, pls. 1–7.

———, 1958 a, The Fauna of Akkeshi Bay, No. 25. Gastropoda: *Publ. Akkeshi Mar. Biol. Stat., No. 8*, pp. 1–39, pls. 1–5.

———, 1958 b, Report on the Mollusca Chiefly Collected by the S. S. Sôyô-Maru of the Imperial Fisheries. Experimental Station on the Continental Shelf Bordering Japan During the Years 1922–1930, Part 3, Lamellibranchia (1): *Publ. Seto Mar. Biol. Lab., Vol. 6, No. 3*, pp. 241–279, pls. 11–13.

HARMER, F. W., 1914, The Pliocene Mollusca of Great Britain, Part II: pp. 201–302, pls. 25–32.

HANZAWA, S. 1954, Tohoku-chiho (Tohoku District), Regional Geology of Japan: *Asakura Book Co., Tokyo*. pp. 1–344.

HATAI, K. and NISIYAMA, S., 1939, Remarks on Certain Fossils from the Borderland of the Japan Sea: *Japan. Jour. Geol. Geogr., Vol. 16, Nos. 1–2*, pp. 123–154, pl. 9.

——— and KOTAKA, T., 1950, *Turritella* from the Shimokita Peninsula: *Jour. Geol. Soc. Japan, Vol. 56, No. 654*, pp. 101–104, text-figs. 1–4.

HAYAKAWA, N., FUNAYAMA, Y., SAITO, K, and KITAMURA, N., 1954, Geology of the Neogene Tertiary between the Western Border of Kitakami-mountainlands and Ôu Backborn Ranges, Iwate Prefecture: *Jour. Tohoku Mining Soc., No. 10*, pp. 1–99.

IDA, K., 1952, A Study of Fossil *Turritella* in Japan: *Rept. No. 150, Geol. Surv. Japan*, pp. 1–62, pls. 1–7.

ITOIGAWA, J., 1955, Molluscan Fauna of the Mizunami Group in the Iwamura Basin: *Mem. Coll. Sci. Univ. Kyoto, Ser. B, Vol. 22, No. 2*, pp. 127–143, pls. 5, 6.

———, 1958, Molluscan Fossils from the Niitsu, Higashiyama and Takezawa Oil-Fields, Niigata Prefecture, Japan: *Mem. Coll. Sci. Univ. Kyoto, Ser. B, Vol. 24, No. 4*, pp. 249–263, pls. 1–2.

KANEHARA, K., 1937, Pliocence Shells from the Teshio Oil-Field, Hokkaido: *Jour. Geol. Soc. Japan, Vol. 44, No. 526*, pp. 703–708, pl. 1.

———, 1940 a, Neogene Fossils from South Echigo: *Bull. Imp. Geol. Surv. Japan, Vol. 27, No. 2*, pp. 1–19, pls. 1–5.

———, 1940 b, Pliocene Shells from the Honjo Oil Field, Akita Prefecture: *Japan. Jour. Geol. Geogr., Vol. 17, Nos. 1–2*, pp. 127–133, pl. 12.

KINOSHITA, T. and ISAHAYA, T., 1934, Catalogue of the Shell Bearing Mollusca from Hokkaido: *Rep. Fish. Surv. Hokkaido Fish Experim. Stat. No. 33*, pp. 1–19, pls. 1–15.

KITAMURA, N., 1959, Tertiary Orogenesis in Northeast Honshu, Japan: *Cont. Inst. Geol. Paleont., Tohoku Univ., No. 49*, pp. 1–98.

KOTAKA, T., 1950, A New *Clinocardium* from Aomori Prefecture: *Short Pap., Inst. Geol. Paleont., Tohoku Univ., No. 2*, pp. 46–50, pl. 5.

KURODA, T., 1931, HOMMA's Shinano-Chubu-Chishitsushi (Geology of the Middle Shinano), *Special Study, Mollusca:* pp. 1–90, pls. 1–13.

MAKIYAMA, J., 1936, The Meisen Miocene of North Korea: *Mem. Coll. Sci. Kyoto Imp. Univ., Ser. B, Vol. 11, No. 4, Art. 8*, pp. 193–228, pls. 4, 5.

MARTIN, B., 1914, Descriptions of New Species of Fossil Mollusca from the Later Marine Neocene of California: *Univ. Calif. Publ., Bull. Dept. Geol., Vol. 8, No. 7*, pp. 181–202, pls. 19, 20.

MIDDENDORFF, A. Th. v., 1851, Sibilische Reise, *2 Bd., Thl. 1, Mollusken*: pp. 163–516, pls. 8–30.

MONTAGUE, G., 1803, Testacea Britannica, or Natural History of British Shells, Marine, Land, and Freshwater: 2 Vols.

NIINO, H., 1934, Discovery of *Thyasira bisecta* CONRAD from Sea Bottom of the Korean Strait; *Jour. Geol. Soc. Japan, Vol. 41, No. 487*, pp. 176–182, pls. 5, 6.

NOMURA, S., 1932, Mollusca from the Raised Beach Deposits of the Kwanto Region: *Sci. Rep. Tohoku Imp. Univ., 2 Ser., Vol. 15, No. 2*, pp. 67–147.

———, 1935, On Some Tertiary Mollusca from Northeast Honshu Japan, Part 2. Fossil Mollusca from the Vicinity of Ogino, Yama-Gun, Hukushima-Ken; *Saito Ho-on Kai Mus., Res. Bull., No. 5*, pp. 101–125, pls. 5–7.

———, 1937, On Some Neogene Fossils from along the Upper Course of the Nikko-gawa, Akumi-Gun, Yamagata-Ken, Northeast Honsyu, Japan: *Saito Ho-on Kai Mus., Res. Bull., No. 13*, pp. 173–178, pl. 24.

———, 1938, Molluscan Fossils from the Tatunokuti Shell Bed Exposed at Gôroku Cliff in the Western Border of Sendai: *Sci. Rep. Tohoku Imp. Univ., 2 Ser., Vol. 19, No. 2*, pp. 235–275, pls. 33–36.

——— and HATAI, K., 1935a, Catalogue of the Shell-bearing Mollusca Collected from the Kesen and Motoyoshi District, Northeast Honsyu, Japan: *Saito Ho-on Kai Mus., Res. Bull., No. 5*, pp. 1–47, pls. 1, 2.

——— and ———, 1935b, Pliocene Mollusca from the Daisyaka Shell-beds in the Vicinity of Daisyaka, Aomori-Ken, Northeast Honsyu, Japan: *Saito Ho-on Kai Mus., Res. Bull., No. 6*, pp. 83–142, pls. 4–8.

——— and ———, 1936, Fossils from the Tanagura Beds in the Vicinity of the Town Tanagura, Hukusima-Ken, Northeast Honsyu, Japan; *Saito Ho-on Kai Mus., Res. Bull., No. 10*, pp. 109–155, pls. 8–17.

——— and ONISHI, H., 1940, Neogene Mollusca from the Sennan District, Miyagi Prefecture, Japan; *Japan. Jour. Geol. Geogr., Vol. 17, Nos. 3–4*, pp. 181–194, pls. 17–19.

——— and ZINBO, N., 1935, Mollusca from the Yanagawa Shell-Beds in the Hukushima Basin, Northeast Honsyu, Japan: *Saito Ho-on Kai Mus., Res. Bull., No. 6*, pp. 151–192, pl. 15.

OINOMIKADO, T. and IKEBE, N., 1935, On Fossil *Macoma calcarea* (GMELIN) from Kazusa: *The Venus, Vol. 5, No. 1*, pp. 14–19.

OLDROYD, I. S., 1924a, The Marine Shells of the West Coast of North America: *Stanf. Univ. Publ. Univ. Ser., Geol. Sci., Vol. 1, No. 1*, pp. 5–247, pls. 1–57.

———, 1924b, Marine Shells of Puget Sound and Vicinity: *Publ. Puget Sound Biol. Stat., Vol. 4*, pp. 1–271, pls. 1–49.

———, 1927, The Marine Shells of the West Coast of North America: *Stanf. Univ. Publ., Univ. Ser., Geol. Sci., Vol. 2, pts 1–3*, pp. 7–941, pls. 1–108.

ONOYAMA, T., 1938, Description of *Lora* species from the Tertiary Formations in Ishikawa and Toyama Prefectures: *The Venus, Vol. 8, No. 2*, pp. 71–81.

OTUKA, Y., 1935a, *Serripes* in Japan: *Jour. Geol. Soc. Japan, Vol. 42, No. 504*, pp. 601–604 (*Trans. Pal. Soc. Japan*), pl. 15, figs. 9, 10, pl. 16.

———, 1935b, The Oti Graben in Southern Noto Peninsula, Japan. (Part 2): *Bull. Earthq. Res. Inst., Vol. 13, pt. 4*, pp. 806–845.

———, 1935c, Ibid., (Part 3): *Ibid.* pp. 846–909, pls. 53–57.

———, 1936, Pliocene Mollusca from Manganzi in Kotomomura, Akita Prefecture, Japan; *Jour. Geol. Soc. Japan, Vol. 43, No. 516* (*Trans. Pal. Soc. Japan*), pp. 726–736, pl. 41.

———, 1939, Mollusca from the Cainozoic System of Eastern Aomori Prefecture, Japan: *Jour. Geol. Soc. Japan, Vol. 46, No. 545*, pp. 23–31, pl. 2.

———, 1949, Fossil Mollusca and Rocks of the Kiyosumi Group exposed at Minatomachi, Chiba Prefecture and its Environs (1st Paper): *Japan. Jour. Geol. Ceogr., Vol. 21, Nos. 1–4*, pp. 295–309, pl. 13.

OZAKI, H., 1958, Stratigraphical and Paleontological Studies on the Neogene and Pleistocene Formations of the Tyôsi District: *Bull. Nat. Sci. Mus., Vol. 4, No. 1,* pp. 1–182, pls. 1–24.

PALMER, K. van W., 1958, Type Specimens of Marine Mollusca Described by P. P. CARPENTER from the West Coast (San Diego to British Columbia): *Geol. Soc. America, Mem. 76,* pp. 1–376, pls. 1–35.

REEVE, L. A., Conchologia Iconica, *Vol. 4 (1848), Vol. 17 (1867).*

RÖMER, E., 1871, Conchilien-Cabinet (von MARTINI und CHEMNITZ): *Bd. 10, Abth. 4, Die Familie der Tellmuscheln, Tellinidae,* pp. 1–291, pls. 1–52.

SAKAKURA, K., 1935, Stratigraphie du bassin d'Obitu-gawa, Prefecture de Tiba, Japon, 2: *Jour. Geol. Soc. Japan, Vol. 42, No. 507,* pp. 753–784.

SOWERBY, G. B., 1915, Descriptions of New Species of Mollusca from Various Localities: *Ann. Mag. Nat. Hist., Ser. 8, Vol. 16,* pp. 164–170, pl. 10.

THIELE, J., 1929, Handbuch der Systematischen Weichtierkunde: *Erster Teil,* pp. 1–376.

TRYON, G. W., Manual of Conchology, *Vol. 3 (1880), Vol. 6 (1873).*

WEAVER, E. C., 1942, Paleontology of the Marine Tertiary Formation of Oregon and Washington, Parts 1–3: *Univ. Washington Publ. Geol., Vol. 5,* pp. 1–789, pls. 1–104.

WENZ, T., 1943, Handbuch der Paläozoologie, Gastropoda: *Teil. 6,* pp. 1201–1506.

WOODRING, W. P., 1928, Miocene Mollusks from Bowden, Jamaica. Part II, Gastropods and Discussion of Results: *Carnegie Inst. Washington, Publ., No. 385.*

YOKOYAMA, M., 1920, Fossils from the Miura Peninsula and its Immediate North: *Jour. Coll. Sci. Imp. Univ. Tokyo, Vol. 39, Art. 6,* pp. 1–193, pls. 1–20.

———, 1922, Fossils from Upper Musashino of Kazusa and Shimosa: *Jour. Coll. Sci. Imp. Univ. Tokyo, Vol. 44, Art. 1,* pp. 1–200, pls. 1–17.

———, 1923, Tertiary Fossils from Kii: *Japan. Jour. Geol. Geogr., Vol. 2, No. 3,* pp. 47–58, pls. 6, 7.

———, 1926a, Fossil shells from Sado: *Jour. Fac. Sci. Imp. Univ. Tokyo, Sec. 2, Vol. 1, Part 8,* pp. 249-312, pls. 32–37.

———, 1926b, Fossil Mollusca from the Oil-Field of Akita: *Jour. Fac. Sci. Imp. Univ. Tokyo, Sec. 2, Vol. 1, pt. 9,* pp. 377–389, pls. 44, 45.

———, 1927, Tertiary Shells from the Coal-Field of Haboro, Teshio: *Jour. Fac. Sci. Imp. Univ. Tokyo, Sec. 2, Vol. 2, pt. 4,* pp. 191–204, pls. 51, 52.

———, 1928, Neogene Shells from the Oil-Field of Higashiyama, Echigo: *Jour. Fac. Sci. Imp. Univ. Tokyo, Sec. 2, Vol. 2, pt. 7,* pp. 351–362, pls. 68, 69.

———, 1931, Tertiary Mollusca from Iwaki: *Jour. Fac. Sci. Imp. Univ. Tokyo, Sec. 2, Vol. 3, pt. 4,* pp. 197–204, pls. 12, 13.

———, 1932, Tertiary Mollusca from the Coalfield of Uryu, Ishikari: *Jour. Fac. Sci. Imp. Univ. Tokyo, Sec. 2, Vol. 3, pt. 6,* pp. 221–247, pls. 1–4.

K. Chinzei

Molluscan Fauna of the Pliocene Sannohe Group of Northeast Honshu, Japan *I. The Faunule of the Kubo Formation.*

Plate IX

Explanation of Plate IX

Figs. 1–5. *Suavodrillia oyamai* CHINZEI, n. sp. ..... p. 116
Figs. 1–3. Holotype (CM 8537), ×2, Loc. 1.
Figs. 4, 5. Paratype (CM 8538), ×3, Loc. 1.

Figs. 6–9. *Antiplanes* (*Rectiplanes*) *sadoensis* (YOKOYAMA) ..... p. 117
Figs. 6, 7. (CM 8540), ×1.5, Loc. 1.
Figs. 8, 9. (CM 8541), ×1.5, Loc. 1.

Figs. 10, 11. "*Macron*" *nipponensis* CHINZEI, n. sp. ..... p. 115
Holotype (CM 8534), ×1, Loc. 2.

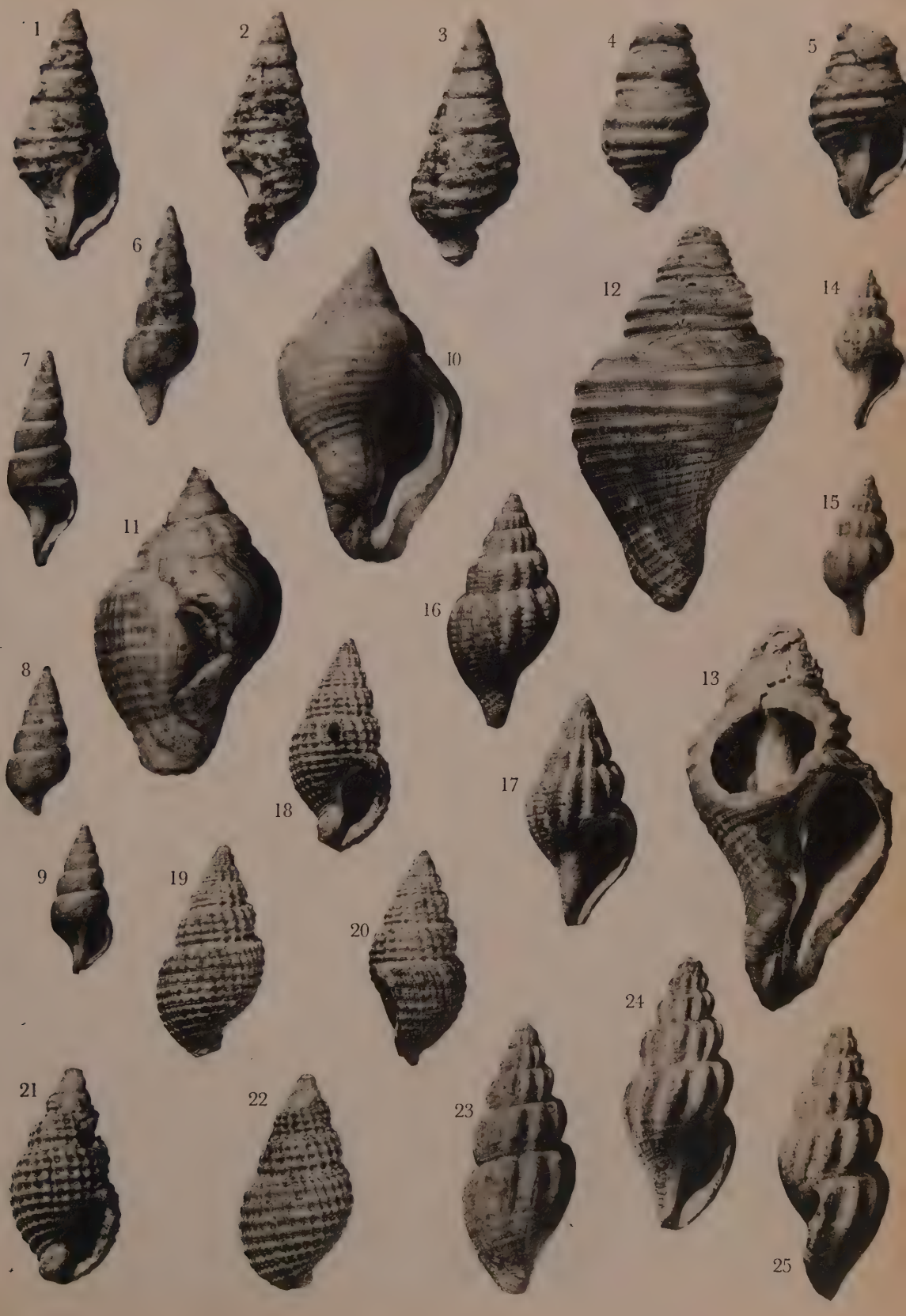
Figs. 12, 13. *Neptunea otukai* CHINZEI, n. sp. ..... p. 112
Holotype (CM 8531), ×1, Loc. 1.

Figs. 14, 15. *Trophonopsis* sp. ..... p. 112
(CM 8530), ×3, Loc. 2.

Figs. 16, 17. *Propebela* sp. ..... p. 119
(CM 8546), ×3, Loc. 1.

Figs. 18–22. *Coraeophos meisensis ninohensis* CHINZEI n. subsp. ..... p. 114
Figs. 18–20. Holotype (CM 8532), ×1.5, Loc. 1.
Figs. 21, 22. Paratype (CM 8533), ×1.5, Loc. 1.

Figs. 23–25. *Propebela* cf. *nakamurai* (ONOYAMA) ..... p. 118
(CM 8543), ×3, Loc. 1.


1
2
3
4
5
6
7
10
12
14
11
15
16
8
13
18
17
9
19
20
24
21
22
23
25

K. Chinzei

Molluscan Fauna of the Pliocene Sannohe Group of Northeast Honshu, Japan *I. The Faunule of the Kubo Formation.*

Plate X

Explanation of Plate X

Figs. 1–4. *Alvania awa* CHINZEI, n. sp. ..... p. 109
Figs. 1, 2. Holotype (CM 8513), ×13, Loc. 1.
Figs. 3, 4. Paratype (CM 8514), ×13, Loc. 1.

Figs. 5–7. *Admete lischkei* (YOKOYAMA) ..... p. 116
Figs. 5, 6. (CM 8535), ×3, Loc. 2.
Fig. 7. (CM 8536), ×3, Loc. 3.

Fig. 8. *Natica* (*Tectonatica*) *russa* GOULD ..... p. 110
(CM 8526), ×1.5, Loc. 2.

Figs. 9, 10. *Menestho nomurai* CHINZEI, n. sp. ..... p. 121
Holotype (CM 8556), ×13.4, Loc. 2.

Figs. 11, 12. *Trophonopsis* aff. *beringi* (DALL) ..... p. 111
(CM 8529), ×3, Loc. 1.

Fig. 13. *Epitonium* (*Boreoscala*) cf. *echigonum* KANEHARA ..... p. 110
(CM 8524), ×2, Loc. 1.

Fig. 14. *Turritella* (*Neohaustator*) *nipponica* YOKOYAMA ..... p. 110
(CM 8521), ×1.5, Loc. 2.

Figs. 15, 16. *Propebela* cf. *turricula* (MONTAGUE) ..... p. 119
(CM 8545), ×3, Loc. 1.

Figs. 17, 18. *Propebela* cf. *kurodai* (ONOYAMA) ..... p. 119
(CM 8544), ×3, Loc. 1.

Figs. 19, 20. *Mohnia* sp. ..... p. 116
(CM 8547), ×3, Loc. 1.

Figs. 21, 22. *Menestho iwatensis* CHINZEI, n. sp. ..... p. 121
Holotype (CM 8555), ×13, Loc. 2.

Figs. 23–25. *Menestho araii* (OTUKA) ..... p. 120
Fig. 23. (CM 8550), ×13, Loc. 1.
Figs. 24, 25. (CM 8549), ×13, Loc. 1.

(Figs. 1–4, 9, 10, 21–25 photo by UEKI)

1
2
5
6
7
13
9
3
14
4
8
15
16
17
10
11
12
18
19
23
20
24
25
21
22

K. Chinzei

Molluscan Fauna of the Pliocene Sannohe Group of Northeast Honshu, Japan *I. The Faunule of the Kubo Formation.*

Plate XI

Explanation of Plate XI

Figs. 1–3. *Nucinella* (*Huxleyia*) *ochiaiensis* CHINZEI, n. sp. ..... p. 123
Figs. 1, 2. Holotype (CM 8566), left valve, ×13.4, Loc. 1.
Fig. 3. Paratype (CM 8567), right valve, ×13.5, Loc. 1.

Figs. 4, 5. *Odostomia* (*Evalea*) cf. *aleutica* DALL and BARTSCH ..... p. 122
(CM 8557), ×13.5, Loc. 1.

Figs. 6, 7. *Venericardia ferruginea ochiaiensis* CHINZEI ..... p. 124
Holotype (CM 8501), right valve, ×2, Loc. 1.

Fig. 8. *Panomya ampla* DALL ..... p. 128
(CM 8580), right valve, ×1, Loc. 2.

Figs. 9, 10. *Clinocardium iwatense* CHINZEI, n. sp. ..... p. 125
Fig. 9. Holotype (CM 8572), right valve, ×1, Loc. 2.
Fig. 10. Paratype (CM 8573), left valve, showing the hinge, ×1, Loc. 2.

Fig. 11. *Macoma calcarea* (GMELIN) ..... p. 126
(CM 8576), right valve, ×1, Loc. 2.

Figs. 12–15. *Clycymeris derelicta* (YOKOYAMA) ..... p. 122
Fig. 12. (CM 8559) left valve, ×1, Loc. 1.
Fig. 13. (CM 8558) right valve, ×2, Loc. 1, showing the hinge and opisthogyral beak.
Fig. 14. Left valve of figs. 13, 15 specimen, ×1.
Fig. 15. The same specimen of fig. 13. ×1.

(Figs. 1–5 photo by UEKI)

1

2

4

5

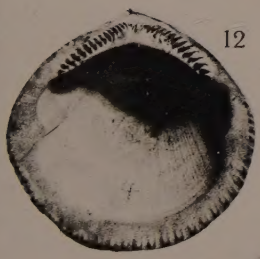
3

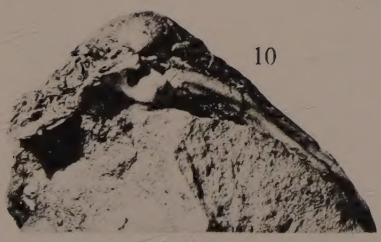
6

7

9

8

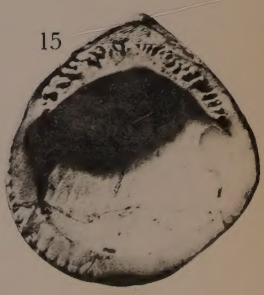

12

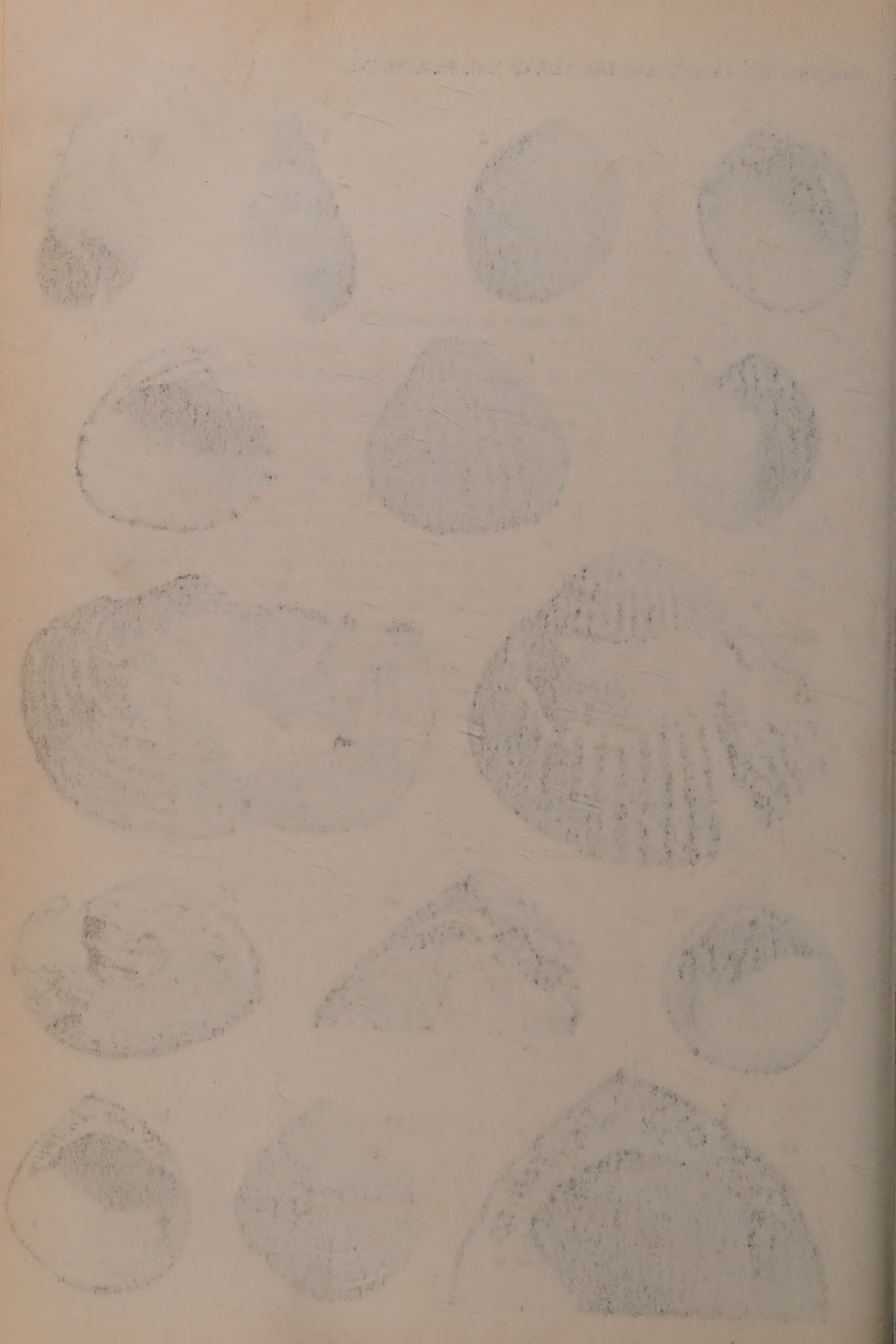

10

11

13

14


15



JOURNAL OF THE FACULTY OF SCIENCE UNIVERSITY OF TOKYO

SECTION I. MATHEMATICS, ASTRONOMY, PHYSICS, CHEMISTRY

Vols. I, II, III, IV, V, VI, VII. Completed.
Vol. VIII, Part 1.

SECTION II. GEOLOGY, MINERALOGY, GEOGRAPHY, GEOPHYSICS

Vols. I, II, III, IV, V, VI, VII, VIII, IX, X. Completed.
Vol. XI, Part 1. (December 20, 1957).

T. KOBAYASHI, Notes on Two Devonian Trilobites from the Kitakami Mountains in Japan 1

T. HANAI, Studies on the Ostracoda from Japan. III. Subfamilies Cytherurinae G. W. MÜLLER (emend. SARS 1925) and Cytheropterinae n. Subfam. 11

N. NASU and Y. SATO, Particle Size Distribution of the Obitsu Delta (The Occurrence of the Steep Marginal Slope of a Small scales Delta) ... 37

A. MIYASHIRO, The Chemistry, Optics and Genesis of the Alkali-Amphiboles. 57

Vol. XI, Part 2. (November 30, 1958).

T. KOBAYASHI, Some Ordovician Gastropods from the Mun'gyŏng or Bunkei District, South Korea (The Cambro-Ordovician Formations and Faunas of South Korea, Part V.) 85

T. HAMADA, Japanese Halysitidae 91

I. HAYAMI, Taxonomic Notes on *Cardinia* with Description of a New Species from the Lias of Western Japan 115

F. SHIDO, Plutonic and Metamorphic Rocks of the Nakoso and Iritōno Districts in the Central Abukuma Plateau 131

A. MIYASHIRO, Regional Metamorphism of the Gosaisyo-Takanuki District in the Central Abukuma Plateau 219

Vol. XI, Part 3. (February 28, 1959).

T. HAMADA, Corallum Growth of the Halysitidae 273

T. HANAI, Studies on the Ostracoda from Japan. IV. Family Cytherideidae SARS 1925 291

K. KANEHIRA, Geology and Ore Deposits of the Chihara Mine, Ehime Prefecture, Japan 309

Vol. XI, Part 4. (December 10, 1959).

A. IIJIMA, On Relationship between the Provenances and Depositional Basins, Considered from the Heavy Mineral Associations of the Upper Cretaceous and Tertiary Formations in Central and Southeastern Hokkaido, Japan 339

T. KOBAYASHI, On Some Ordovician Fossil from Northern Malaya and Her Adjacence 387

T. HANAI, Studies on the Ostracoda from Japan. V. Subfamily Cytherinae, DANA, 1852 (emend.) 409

T. HANAI, Studies on the Ostracoda from Japan. Histrical Review with Bibliographic Index of Japanese Ostracoda 419

K. KONISHI, Notes on Some Japanese Permian and Cretaceous Algae and thier Stratigraphic Setting. (Studies on the Paleozoic Algae of Japan, 4) 441

SECTION III. BOTANY

Vols. I, II, III, IV, V, VI. Completed.
Vol. VII, Parts 1-8.

SECTION IV. ZOOLOGY

Vol. I, II, III, IV, V, VI, VII. Completed.
Vol. VIII, Parts 1-3.

SECTION V. ANTHROPOLOGY

Vol. I. Completed.
Vol. II, Part 1.

CONTENTS

	Page
T. KOBAYASHI and A. TOKUYAMA: *Daonella* in Japan	1～ 26
T. KOBAYASHI and A. TOKUYAMA: The Halobiidae from Thailand	27～ 30
I. HAYAMI: Lower Liassic Lamellibranch Fauna of the Higashinagano Formation in West Japan	31～ 84
F. SHIDO and A. MIYASHIRO: Hornblendes of Basic Metamorphic Rocks	85～102
K. CHINZEI: Molluscan Fauna of the Pliocene Sannohe Group of Northeast Honshu, Japan. 1. The Faunule of the Kubo Formation	103～132

The JOURNAL is on sale at

MARUZEN CO., LTD.

6, Nihonbashi Tōri-Nichōme, Chuō-Ku, Tokyo

Price in Tokyo: Yen 290 for this Part.

昭和三十四年十二月十日印刷
昭和三十四年十二月十五日発行

編集兼発行者　東京大學

印刷者　小山恵市　東京都新宿区筑土八幡町八番地

印刷所　千代田出版印刷株式会社　東京都新宿区筑土八幡町八番地

売捌所　丸善株式会社　東京都中央区日本橋通二丁目六番地